RECORDING OSCILLOGRAPH

OPERATION AND MAINTENANCE MANUAL

MP MASTER
MA30169

CONSOLIDATED ELECTRODYNAMICS CORPORATION
PASADENA, CALIFORNIA

5 New Galvanometers

By Consolidated Engineering

higher

efficiency
frequency response
sensitivity
performance

Consolidated Engineering now offers the first five types of a new "high-performance" series in the 7-300 line of recording galvanometers. The result of a concentrated research and development program, these galvanometers combine sensitivities and frequencies higher than any previously available in a single instrument.

Until recently it was generally believed that the practical performance limits of miniature d'Arsonval recording galvanometers had been reached. Basic physical laws dictate that high-frequency response and high sensitivity are mutually incompatible. Ordinarily, one of these qualities is obtained only at the expense of the other. The attainment of both high sensitivity and high-frequency response in a single galvanometer, therefore, represents a signal achievement.

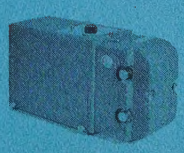
These new instruments permit accurate recording of dynamic data up to 200 cps with no signal amplification between resistance strain gages and recording oscillograph. This approximately doubles the former maximum frequency range for direct recording. For the same frequency range, sensitivity has been *quadrupled* and a completely new field of low-output strain-gage applications opened.

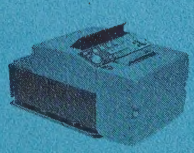
The availability of new types of materials in wire, insulation, and cements, combined with advanced microscopic assembly techniques, has made the high-performance family possible. New balance standards make the instruments particularly suited to flight-test or mobile applications. All five types match the commonly used strain-gage bridge resistances of 120, 180, or 350 ohms; the need for impedance-matching networks is therefore eliminated.

THE NEW HIGH-PERFORMANCE GALVANOMETERS MAY BE USED IN ANY OF THESE CEC OSCILLOGRAPHS.

TYPE 5-114

TYPE 5-116


TYPE 5-117


TYPE 5-119

SPECIFICATIONS OF THE NEW HIGH-PERFORMANCE SERIES GALVANOMETERS

7-300 (1)	Undamped Natural Frequency cps	(Flat (±5%) Frequency Range cps	External Damping Resistance Required Ohm (2)	Nominal Coil Resistance Ohms	Sensitivity At 11.5 Inch Optical Arm				Static Balance (4)		Maximum Safe Current m.a.
					Undamped d.c. Sensitivity		System Voltage Sensitivity (3)		Standard	Special	
					μa/in	in/μa	mv/in	in/mv			
7-342	225	0-135	350	83	10.8	.0926	4.673	.214	0.008	(5)	15
7-343	335	0-200	120	55	34.7	.0288	6.060	.165	0.008	(5)	15
7-344	150	0-90	180	36	10.2	.0980	2.20	.455	0.008	(5)	15
7-345	335	0-200	180	79	24.3	.0411	6.29	.159	0.008	(5)	15
7-436	320	0-190	350	52	27.2	.0367	10.94	.0914	0.008	(5)	15

The high-performance galvanometers are designed to provide the maximum possible frequency response compatible with sensitivities adequate for direct recording. The 7-342 and 7-345 have been designed with system voltage sensitivity identical to their 7-315 and 7-318 counterparts, but feature greatly extended frequency ranges. This achieves the very important characteristic of electrical interchangeability with no circuit revision.

The 7-344 has the same natural frequency as its 7-318 counterpart, but with greatly increased sensitivity, permitting recording of very-low-level signals.

The 7-343 and 7-346 have adequate sensitivity for direct-recording applications with emphasis on the maximum attainable frequency range. These two types are designed for use with 120-ohm and 350-ohm bridges, respectively.

SPECIFICATIONS OF THE REGULAR TYPE 7-300 GALVANOMETERS

7-300 (1)	Undamped Natural Frequency cps	Flat (±5%) Frequency Range cps	External Damping Resistance Required Ohm (2)	Nominal Coil Resistance Ohms	Sensitivity At 11.5 Inch Optical Arm				Static Balance (4)		Maximum Safe Current m.a.
					Undamped d.c. Sensitivity		System Voltage Sensitivity (3)		Standard	Special	
Magnetically Damped Galvanometers					μa/in	in/μa	mv/in	in/mv			
7-325	18.5	0-11	350	18.5	7.9	0.127	2.92	0.343	0.050	0.025	15
7-339	50	0-30	350	30	4.6	0.217	1.75	0.572	0.032	0.016	15
7-315	100	0-60	350	33	12.2	0.082	4.67	0.214	0.016	0.008	15
7-312	100	0-60	350	40	29.9	0.033	11.62	0.086	0.016	0.008	25
7-318	150	0-90	180	26	30.6	0.032	6.29	0.159	0.016	0.008	25
7-338	210	0-125	120	24	58.3	0.017	8.40	0.119	0.016	0.008	50
7-324	300	0-180	83	40	270.0	0.0037	33.33	0.030	0.016	0.008	50
7-319	585	0-350	25	22	462.0	0.0022	21.70	0.046	0.016	0.008	50
Fluid-Damped Galvanometers (6)					ma/in	in/ma	v/in	in/v			
7-320	1000	0-600	200	24	2.32	0.431	0.52	1.92	0.010	(5)	100
7-323	1000	0-600	1000	24	2.50	0.400	2.56	0.390	0.010	(5)	100
7-316	2000	0-1200	200	24	9.17	0.109	2.05	0.487	0.008	(5)	100
7-317	3700	0-2200	28	24	41.3	0.025	2.15	0.464	0.008	(5)	100
7-326	5000	0-3000	55	52	32.10	0.031	3.44	0.291	0.008	(5)	100
7-353	An integrating-type galvanometer whose response is inversely proportional to frequency from 8 to 800 cps. See Bulletin 1517.										

NOTES: (1) This chart provides accurate specification of the Series 7-300 Galvanometers.
(2) For 64% critical damping (nominal).
(3) The System Voltage sensitivity relates the galvanometer trace deflection (inches) on the record to the open-circuit voltage of a transducer having a source resistance equal to (2) above. (Previous CEC galvanometer characteristics charts have stated voltage sensitivity in terms of voltage applied to the coil. These values should not be compared to the present sensitivities, since the two are based on different circuitry conditions.)
(4) Deflection of trace in inches per "g" at 11.5 inch optical arm.
(5) Not furnished. Standard balance normally satisfactory for all test requirements.

Mechanically and electrically the 7-300 galvanometers are interchangeable with the well-known 7-200's, and may be used in all currently manufactured Consolidated recording oscillographs. Fourteen individual models offer flat frequency ranges from 0-11 to 0-3000 cps. Undamped d-c current sensitivities range from 4.6 microamperes per inch to 400 milliamperes per inch, both figures being based upon deflection of a trace on the record at an 11.5-inch optical base.

CONSOLIDATED ENGINEERING CORPORATION

300 North Sierra Madre Villa, Pasadena, California

Sales and Service Offices Located in: *Albuquerque, Atlanta, Boston, Buffalo, Chicago, Dallas, Detroit, New York, Pasadena, Philadelphia, San Francisco, Seattle, Washington, D. C.*

CEC price list

CONSOLIDATED ENGINEERING
CORPORATION
300 North Sierra Madre Villa, Pasadena 15, California
OFFICES IN: *Albuquerque, Atlanta, Buffalo, Chicago, Dallas, Detroit, New York, Pasadena, Philadelphia, Seattle, Washington, D. C.*

EFFECTIVE AUGUST 1, 1955

TYPE 7-300 GALVANOMETERS AND ACCESSORIES

SPECIFICATIONS OF THE NEW HIGH-PERFORMANCE SERIES GALVANOMETERS

7-300 (1)	Undamped Natural Frequency cps	(Flat (±5%) Frequency Range cps	External Damping Resistance Required Ohm (2)	Nominal Coil Resistance Ohms	Sensitivity At 11.5 Inch Optical Arm				Static Balance (4)		Maximum Safe Current m.a.	Unit Price
					Undamped d.c. Sensitivity		System Voltage Sensitivity (3)		Standard	Special		
					μa/in	in/μa	mv/in	in/mv				
7-342	225	0-135	350	83	10.8	.0926	4.673	.214	0.008	(5)	15	$225.00
7-343	335	0-200	120	55	34.7	.0288	6.060	.165	0.008	(5)	15	225.00
7-344	150	0-90	180	36	10.2	.0980	2.20	.455	0.008	(5)	15	225.00
7-345	335	0-200	180	79	24.3	.0411	6.29	.159	0.008	(5)	15	225.00
7-346	320	0-190	350	52	27.2	.0367	10.94	.0914	0.008	(5)	15	225.00

SPECIFICATIONS OF THE REGULAR TYPE 7-300 GALVANOMETERS

7-300 (1)	Undamped Natural Frequency cps	Flat (±5%) Frequency Range cps	External Damping Resistance Required Ohm (2)	Nominal Coil Resistance Ohms	Sensitivity At 11.5 Inch Optical Arm				Static Balance (4)		Maximum Safe Current m.a.	Unit Price
					Undamped d.c. Sensitivity		System Voltage Sensitivity (3)		Standard	Special		
Magnetically Damped Galvanometers					μa/in	in/μa	mv/in	in/mv				
7-325	18.5	0-11	350	18.5	7.9	0.127	2.92	0.343	0.050	0.025	15	$172.00
7-339	50	0-30	350	30	4.6	0.217	1.75	0.572	0.032	0.016	15	172.00
7-315	100	0-60	350	33	12.2	0.082	4.67	0.214	0.016	0.008	15	197.00
7-312	100	0-60	350	40	29.9	0.033	11.62	0.086	0.016	0.008	25	172.00
7-318	150	0-90	180	26	30.6	0.032	6.29	0.159	0.016	0.008	25	187.00
7-338	210	0-125	120	24	58.3	0.017	8.40	0.119	0.016	0.008	50	187.00
7-324	300	0-180	83	40	270.0	0.0037	33.33	0.030	0.016	0.008	50	162.00
7-319	585	0-350	25	22	462.0	0.0022	21.70	0.046	0.016	0.008	50	162.00
Fluid-Damped Galvanometers (6)					ma/in	in/ma	v/in	in/v				
7-320	1000	0-600	200	24	2.32	0.431	0.52	1.92	0.010	(5)	100	165.00
7-323	1000	0-600	1000	24	2.50	0.400	2.56	0.390	0.010	(5)	100	165.00
7-316	2000	0-1200	200	24	9.17	0.109	2.05	0.487	0.008	(5)	100	165.00
7-317	3700	0-2200	28	24	41.3	0.025	2.15	0.464	0.008	(5)	100	165.00
7-326	5000	0-3000	55	52	32.10	0.031	3.44	0.291	0.008	(5)	100	190.00
7-353	An integrating-type galvanometer whose response is inversely proportional to frequency from 8 to 800 cps. See Bulletin 1517.											225.00

NOTES: (1) This chart provides accurate specification of the Series 7-300 Galvanometers.
(2) For 64% critical damping (nominal).
(3) The System Voltage sensitivity relates the galvanometer trace deflection (inches) on the record to the open-circuit voltage of a transducer having a source resistance equal to (2) above. (Previous CEC galvanometer characteristics charts have stated voltage sensitivity in terms of voltage applied to the coil. These values should not be compared to the present sensitivities, since the two are based on different circuitry conditions.)
(4) Deflection of trace in inches per "g" at 11.5 inch optical arm.
(5) Not furnished. Standard balance normally satisfactory for all test requirements.

Unused slots between active galvanometers may be filled with Types 7-002 or 7-003 listed below. The Type 7-003 is used to maintain specification sensitivity and magnetic-damping characteristics for extremely high-accuracy tests. The Type 7-002 incorporates standard pole pieces to maintain uniform flux and does not affect the characteristics of the active galvanometers being used.

TYPE 7-003 DUMMY GALVANOMETER . . . . . $ 15.00
Dummy galvanometers (with no internal mechanism) are equipped with standard pole pieces.

TYPE 7-002 STATIC GALVANOMETER REFERENCE TRACE 50.00
Static galvanometer reference traces (equipped only with a movement mirror) are used to provide fixed reference traces at any point on the record.

PART NO. 17954 DYNAMIC REFERENCE TRACE 120.00
(.45"/ma) Mounts on right hand side of oscillograph block.

PART NO. 22261 DYNAMIC REFERENCE TRACE 120.00
(.004"/ma) Mounts on right hand side of oscillograph block.

PART NO. 25170 DYNAMIC REFERENCE TRACE 120.00
(.004"/ma) Mounts on left hand side of oscillograph block.

These dynamic reference traces are equipped with a live movement and mount at the end of the galvanometer block to record external timing pulses, etc.

Plug-in damping resistors are available for use in circuits where the driving-source impedance does not provide proper galvanometer damping. Units are furnished on order to the specific resistance value required and are connected in either shunt or series form.

SHUNT RESISTOR PART NO. 17256-- (specify ohms required)

SERIES RESISTOR PART NO. 17923-- (specify ohms required)

QUANTITY	1-25	26-50	51 or more
UNIT PRICE	$6.60	$5.50	$4.75

GALVANOMETER TOOLS

PART NO.	DESCRIPTION	PRICE
31333	Galvanometer Lifting Tool (all oscillographs)	$ 7.50
21606	Galvanometer Wrench Lateral & Timing Adjustment (5-114, 5-115, 5-116, 5-119)	5.75
26014	Galvanometer Wrench Spot Brilliance Adjustment (5-117, 5-118) & Lateral Adjustment	5.50
28038	Galvanometer Wrench Spot Brilliance Adjustment (5-114, 5-115, 5-116)	3.00
31736	Galvanometer Wrench Spot Brilliance Adjustment (5-119)	3.50

TERMS: Net 10th prox.

TAXES: All prices are subject to state and local taxes.

NOTICE: Prices subject to change without notice. Prices are f.o.b. Shipping Point.

CEC **price list**

Consolidated Electrodynamics
CORPORATION
300 North Sierra Madre Villa, Pasadena, California
OFFICES IN PRINCIPAL CITIES THROUGHOUT THE WORLD

Effective January 1, 1958

GALVANOMETER SPECIFICATIONS—TYPE 7-300 SERIES

Type 7-300	External Damping Resistance Required (1)	Undamped Natural Frequency	Flat (±5%) Frequency Range	Nominal Coil Resistance	Sensitivity At 11.5 Inch Optical Arm				Static Balance (3)		Maximum Safe Current	Unit Price (*4)
					Undamped d-c Sensitivity		System Voltage Sensitivity (2)		Standard	Special		
	Ohms	cps	cps	Ohms					in/g	in/g	ma	
Magnetically Damped					μa/in	in/μa	mv/in	in/mv				
7-349	350	10	0-6	130	1.62	0.617	0.778	1.286	0.026		15	$195.00
7-325	350	18.5	0-11	18.5	7.9	0.127	2.92	0.343	0.050	0.025	15	135.00*
7-351	350	20	0-12	31	2.67	0.375	1.02	0.982	0.016		15	165.00
7-339	350	50	0-30	30	4.61	0.217	1.75	0.572	0.032	0.016	15	150.00*
7-341	350	100	0-60	47	6.12	0.163	2.43	0.411	0.012		10	180.00
7-315	350	100	0-60	33	12.2	0.0820	4.67	0.214	0.016	0.008	15	165.00*
7-312	350	100	0-60	40	29.9	0.0334	11.7	0.0858	0.016	0.008	25	135.00*
7-342	350	225	0-135	83	10.7	0.0935	4.67	0.214	0.008		15	195.00
7-346	350	320	0-190	60	26.7	0.0375	10.9	0.0914	0.008		15	180.00
7-344	180	150	0-90	45	9.75	0.103	2.20	0.455	0.008		15	180.00
7-318	180	150	0-90	26	30.6	0.0327	6.29	0.159	0.016	0.008	25	150.00*
7-345	180	335	0-200	79	24.3	0.0411	6.29	0.159	0.008		15	180.00
7-348	120	100	0-60	95	6.8	0.147	1.46	0.683	0.008		10	180.00
7-338	120	210	0-125	24	58.3	0.0172	8.40	0.119	0.016	0.008	50	150.00*
7-347	120	225	0-135	90	15.1	0.0662	3.17	0.315	0.008		15	165.00
7-343	120	335	0-200	61	33.3	0.0300	6.06	0.165	0.008		15	180.00
7-324	83	300	0-180	40	270	0.00370	33.3	0.030	0.016	0.008	50	120.00*
7-319	25	585	0-350	25	435	0.00230	21.7	0.046	0.016	0.008	50	135.00*
Fluid Damped					ma/in	in/ma	v/in	in/v				
7-364	200	833	0-500	72	0.400	2.50	0.107	9.37	0.008		50	165.00
7-323	1000	1000	0-600	24	2.50	0.400	2.56	0.390	0.010		100	135.00
7-320	200	1000	0-600	24	2.32	0.431	0.521	1.92	0.010		100	135.00
7-363	200	1670	0-1000	66	2.0	0.50	0.533	1.875	0.005		100	165.00
7-316	200	2000	0-1200	24	9.17	0.109	2.05	0.487	0.005		100	135.00
7-317	28	3700	0-2200	24	41.4	0.0242	2.16	0.464	0.005		100	135.00
7-362	200	4150	0-2500	69	12.0	0.0833	3.23	0.31	0.005		100	165.00
7-326	55	5000	0-3000	52	32.2	0.0311	3.44	0.291	0.005		100	150.00
7-361	55	8000	0-5000	57	46.1	0.0217	5.29	0.189	0.005		100	205.00
HIGH-TEMPERATURE GALVANOMETERS												
Magnetically Damped					μa/in	in/μa	mv/in	in/mv				
7-350	350	20	0-12	36.1	2.67	0.375	1.03	0.970	0.020		15	225.00
7-352	350	100	0-60	42.1	12.1	0.0826	4.74	0.211	0.016		15	215.00
7-354	180	150	0-90	36.1	29.9	0.0344	6.45	0.155	0.012		25	205.00
7-355	120	225	0-135	121	14.2	0.0704	3.42	0.292	0.008		15	225.00
Fluid Damped					ma/in	in/ma	v/in	in/v				
7-381	1000	1000	0-600	28	2.5	0.40	2.56	0.390	0.010		100	205.00
7-382	55	5000	0-3000	65	32.2	0.0311	3.86	0.259	0.005		100	215.00
SPECIALIZED GALVANOMETERS												
7-353	An integrating-type galvanometer whose response is inversely proportional to frequency from 8 to 800 cps. See Bulletin 1517C.											205.00
7-370	A Computing-type galvanometer whose response is either the product, sum, or difference between two signals. Primarily used for power measurement. Flat response from 0-800 cps. See Bulletin 1605.											375.00

NOTES:

(1) For 64% critical damping.

(2) The System Voltage sensitivity relates the galvanometer trace deflection (inches) on the record to the open-circuit voltage of a transducer having a source resistance equal to (1) above. (Previous CEC galvanometer-characteristics charts have stated voltage sensitivity in terms of voltage applied to the coil. These values should not be compared to the present sensitivities, since the two are based on different circuitry conditions.)

(3) Deflection of trace in inches per "g" at 11.5-inch optical arm.

(*4) Add $15.00 for special balance.

Unused slots between active galvanometers may be filled with Types 7-002 or 7-003 listed below. The Type 7-003 is used to maintain specification sensitivity and magnetic-damping characteristics for extremely high-accuracy tests. The Type 7-002 incorporates standard pole pieces to maintain uniform flux and does not affect the characteristics of the active galvanometers being used.

TYPE 7-003 DUMMY GALVANOMETER . . . . . .$ 15.00

Dummy galvanometers (with no internal mechanism) are equipped with standard pole pieces.

TYPE 7-002 STATIC GALVANOMETER REFERENCE TRACE 50.00

Static galvanometer reference traces (equipped only with a static mirror) are used to provide fixed reference traces at any point on the record.

TYPE 7-004 DYNAMIC REFERENCE TRACE 120.00

Dynamic reference trace galvanometer (equipped with movement mirror) 28 ma per inch employed to provide dynamic reference trace on the record.

Plug-in damping resistors are available for use in circuits where the driving-source impedance does not provide proper galvanometer damping. Units are furnished on order to the specific resistance value required and are connected in either shunt or series form.

SHUNT RESISTOR PART NO. 17256-- (specify ohms required) . . . . . $ 7.25

SERIES RESISTOR PART NO. 17923-- (specify ohms required) 7.25

TERMS: Net 30 days.

TAXES: All prices are subject to state and local taxes.

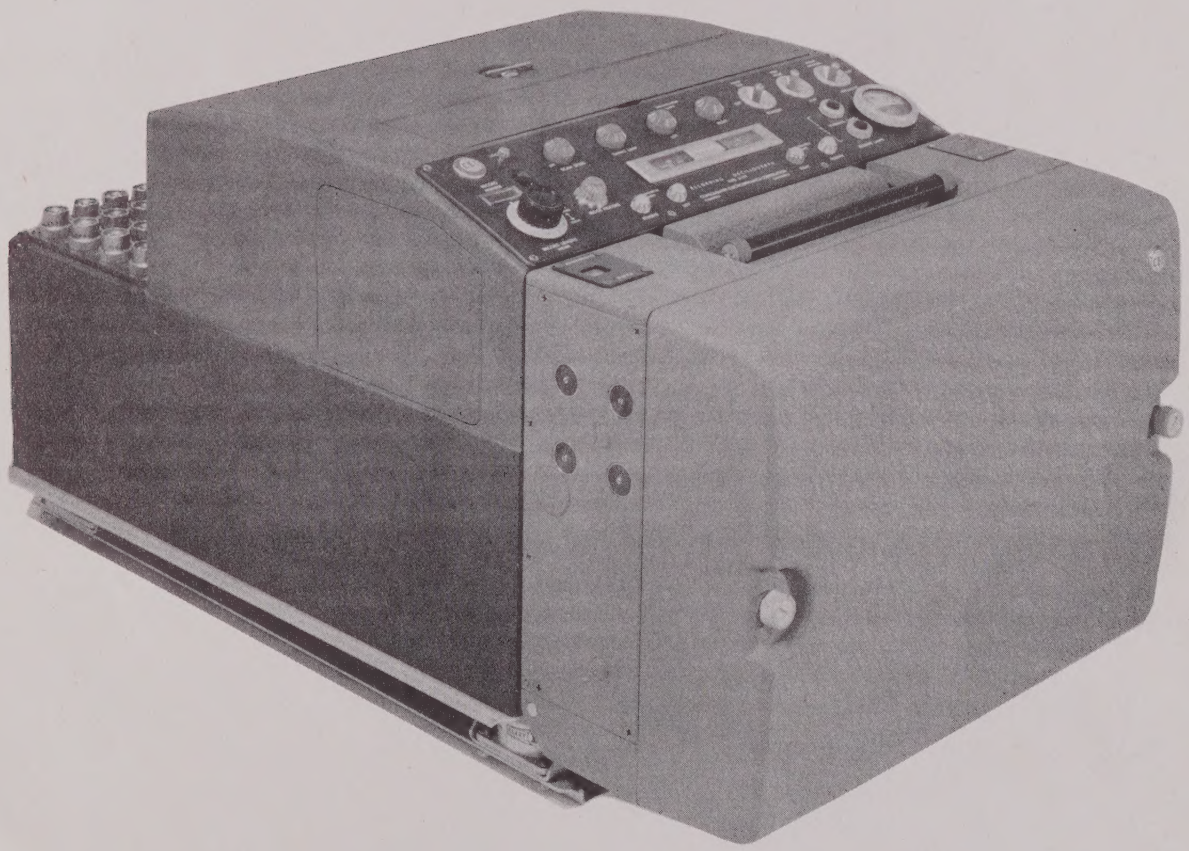
NOTICE: Prices subject to change without notice. Prices are f. o. b. Shipping Point.

I. E. L.

TYPE 5-119P4

RECORDING OSCILLOGRAPH

OPERATION AND MAINTENANCE MANUAL



CONSOLIDATED ELECTRODYNAMICS CORPORATION
360 Sierra Madre Villa, Pasadena, California

SALES AND SERVICE OFFICES LOCATED IN PRINCIPAL CITIES THROUGHOUT THE WORLD

CEC

This Manual is for the 5-119P4
Recording Oscillograph, Lot 15.

5-119P4
2061 10-59

DATA PROCESSING

SALES AND SERVICE OFFICES

Albuquerque, New Mexico
301 Washington, S.E.
Phone: ALpine 5-8671

Atlanta, Georgia
3272 Peachtree Road, N.E.
Phone: CEdar 3-4467

Bellevue, Washington
808 - 106th Ave., N.E.
Phone: GLencourt 4-9370

Beverly Hills, California
291 S. La Cienega Blvd.
Phone: OLeander 5-8414

Boston, Massachusetts
31 St. James Avenue
Phone: HAncock 6-1354

Buffalo, New York
2070 Sheridan Drive
Phone: VIctoria 1655

Chicago, Illinois
2540 W. Peterson Avenue
Phone: ROgers Park 1-4235

Columbus, Ohio
3770 N. High Street
Phone: AMherst 7-7568

Dallas, Texas
703 Exchange Bank Building
Phone: FLeetwood 1-9997

Denver, Colorado
2145 S. Clermont
Phone: SKyline 6-1071

Hasbrouck Heights, New Jersey
345 Boulevard
Phone: ATlas 8-2055

Orlando, Florida
2400 E. Colonial Drive
Phone: CHerry 1-2131

Palo Alto, California
4015 Fabian Way
Phone: DAvenport 6-8350

Pasadena, California
1095 East Green Street
Phone: SYcamore 5-4371

Philadelphia, Pennsylvania
101 North 33rd Street
Phone: EVergreen 2-1529

San Diego, California
3266 Rosecrans Street
Phone: ACademy 3-8136

St. Louis, Missouri
1401 Brentwood Blvd.
Phone: WOodland 2-3542

Washington, D.C.
711 - 14th Street, N.W.
Phone: REpublic 7-3697

Export Sales
360 Sierra Madre Villa
Pasadena, California

TABLE OF CONTENTS

Page No.

PART I. INSTRUMENT DESCRIPTION

A. Introduction 1
B. System Description 1
C. Component Description - The Oscillograph 2
D. Performance Specifications 6

PART II. INSTALLATION INSTRUCTIONS

Packing List 1

PART III. GALVANOMETERS

A. Galvanometer Selection 1
B. Direction of Galvanometer Spot Deflection 2
C. Damping 2
D. Galvanometer Markings 2
E. Galvanometer Installation, Connection, Adjustment, and Removal 3

PART IV. SELECTION OF RECORDING MATERIALS AND ILLUMINATOR VOLTAGE SETTINGS

A. General 1
B. Writing Speed Versus Illuminator Voltage 1
C. Estimation of Maximum Spot Velocity 1
D. Selection of Recording Material and Illuminator Voltage 1
E. Processing Procedure 2
F. Oscillograph Processor 4

PART V. OPERATING INSTRUCTIONS

A. Preliminary Procedure 1
B. Loading the Magazine 3
C. System Calibration 4
D. Final Circuit Check 4
E. Attaching Magazine to Oscillograph 4
F. Recording 5
G. Developing the Record 5

PART VI. ADJUSTMENT AND MAINTENANCE

A. Normal Maintenance Procedures 1
B. Periodic Maintenance 6
C. Maintenance Guide 7
D. Magazine Servicing, Cat. No. 5006A, 5-032 11
Reference Parts List 14

PART VII. CABLING

PART VIII. PARTS LIST

A. Replacement Parts Ordering 1
B. Factory Repairs 1

PART VIII. PARTS LIST (Continued) Page No.

C. Field Service Plans 1
Modular Breakdown
Replacement Parts List 2

PART IX. SCHEMATICS

PART X. ACCESSORIES

A. Type 11-108 Remote Control 1
B. Plug-In Damping Resistors 2
C. Measurement - Recording Systems 3
D. Transducers 3
E. Oscillogram Processor, Type 23-109A 3
F. Dummy Galvanometer 3
G. Static Galvanometer Reference Trace 3
H. Dynamic Reference Trace 4
I. Vertical Rack Mounting 4
J. Horizontal Drawer Mounting 4
K. DATARITE Magazine, Type 5-036B 4

PART XI. APPENDIX

PART I

INSTRUMENT DESCRIPTION

A. INTRODUCTION

The recording oscillograph is an instrument capable of making a record of any static or dynamic phenomenon which is convertible to an analog voltage. An analytical tool, it is designed to measure various vibrations and stresses. Sensing of these phenomena is usually accomplished with low-voltage output pickups (transducers or strain gages), which translate mechanical variations into electrical impulses.

Electrical impulses produced by the pickups may be fed into an amplifier or bridge balance where the received signal is amplified before being introduced into the oscillograph. Once within the oscillograph, the signal is fed to a highly sensitive galvanometer. Light from an illuminator is reflected by the galvanometer mirror through a simple optical system which produces a spot of light on a moving strip of photographic material. By using various combinations of light intensity and record speed, clear legible records are obtainable over a wide range of applications.

The Type 5-119 Recording Oscillograph has been developed by Consolidated Electrodynamics Corporation to meet requirements for diversified fields. At present there are seven models of Type 5-119 with almost identical construction and operation except for drive motors and minor circuit changes.

These are: Types 5-119P4-36 and 5-119P4-50 which operate from 115-volt, 60-cycle alternating current; Types 5-119P3-36 and 5-119P3-50 which operate from 26-volt direct current; and Types 5-119P4-36V and 5-119P4-50V which operate from 115-volt, 60-cycle alternating current and use a high-actinic light source for direct printing. Type 5-119P7-50MB is for use in applications involving the presence of explosive mixtures; it operates from 200-volt, 400-cycle, 3-phase alternating current.

This manual is for Types 5-119P4-36 (36 traces) and 5-119P4-50 (50 traces).

Internal construction allows for easy maintenance and repair as well as compact design and snug fit of components. Each functional assembly may be removed for service, repair, or replacement without disturbing other functional assemblies. All controls and indicators are located on a single front panel.

Static reference traces, record length pre-selection, automatic switch-over to reserve lamps in case of main lamp failure, trace identification, viewing and scanning system, sequential event numbering, and vibration isolation elements are standard equipment. Accessories are briefly described in a special section of the manual.

Operation of the 5-119P4 Recording Oscillograph should be undertaken only after thoroughly studying both this manual and the instrument itself. Not only will this familiarization help the user to obtain records of optimum quality and value; it will also reduce the possibility of unnecessary damage to the instrument.

B. SYSTEM DESCRIPTION

1. The 5-119P4 Oscillograph is for operation from a 115-volt, 60-cycle a-c power source. It is composed of five principal functional groups: the galvanometer system, the light and optical system, the mechanical drive system, the timing system, and the record and event numbering systems.

    a. The galvanometer system: the 5-119P4 Oscillograph is designed to provide 36 or 50 active traces and four or two static reference traces. The static reference traces are mounted on the outboard side of each galvanometer block. Two Alnico V blocks of the galvanometer system are thermostatically controlled at 100°F.

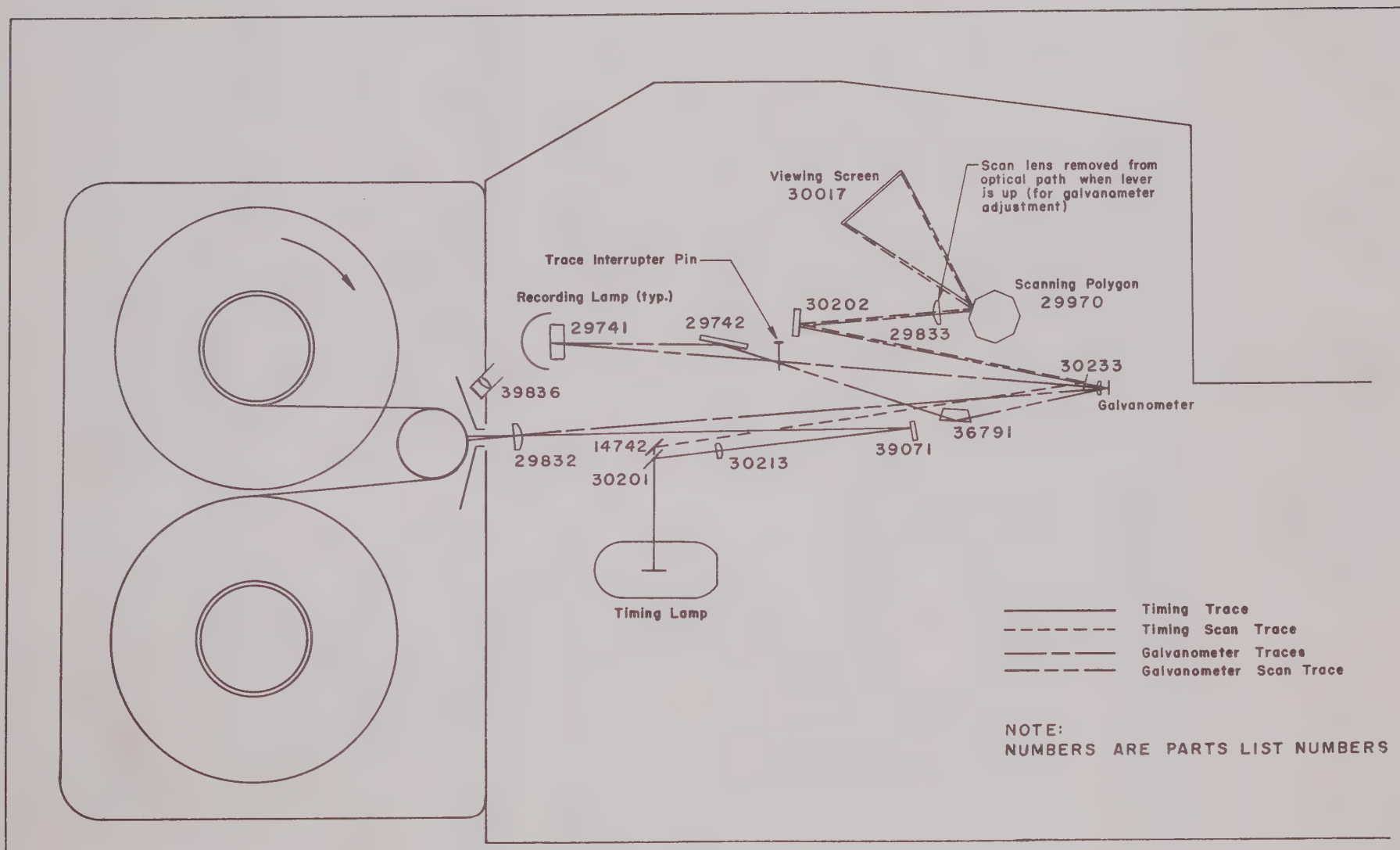


FIG. 1:01
OPTICAL DIAGRAM

5-119P4
6-59 2061

b. The light source and optical system: the light source consists of two 11-volt tungsten filament lamps. Figure 1:01 shows the light path from these lamps through the optical system. The light beam is divided into two basic paths. One of these goes through the collimating lens to form an image of the trace on the record. The other is directed to the calibrated viewing screen situated in the top of the oscillograph. Variables in record emulsion and writing speeds are provided for by galvanometer lamp adjustments. These are accomplished by two potentiometers with thumb-trols on the front of the oscillograph to control the light to the galvanometers of the left or right bank. Trace identification is of the interrupted beam type.

c. Mechanical drive system: a motor- and gear-driven transmission provide the mechanical motion necessary to maintain constant record speed. These are constructed as a modular unit and are located in the lower section of the oscillograph. Manual gear changes on the transmission and a jump-speed system provide a selection of speeds necessary for maximum record resolution.

d. The timing system: this system uses a slotted disc rotating in front of a tungsten light source. The resulting light flashes are used to photographically produce on the record media timing lines at intervals of 0.01 and 0.1 per second. Every tenth line may be accentuated at the operator's discretion. The timing disc is situated in the bottom front of the oscillograph and to the right of the change gears.

e. The record and event numbering systems: two independent systems are incorporated in the oscillograph, one for record identification, the other for marking special events on the record.

2. 5-006A Record Magazine

The magazine includes means for attachment to the 5-119P4 Oscillograph and for transferring the drive power from the 5-119P4 to the record-metering, and takeup rollers. Indication of remaining unexposed recording material, and record jamming is provided. There is a shutter which closes light-tight when the magazine is removed from the oscillograph.

3. 11-108 Remote Control Unit

This unit is a separate accessory and is described in the section labeled ACCESSORIES.

C. COMPONENT DESCRIPTION - THE OSCILLOGRAPH

This instrument has been thoroughly inspected and tested and should be ready for immediate operation when received; however, the operator should conduct his own inspection to satisfy himself that no damage has occurred during shipment and that adjustments are in accordance with his requirements.

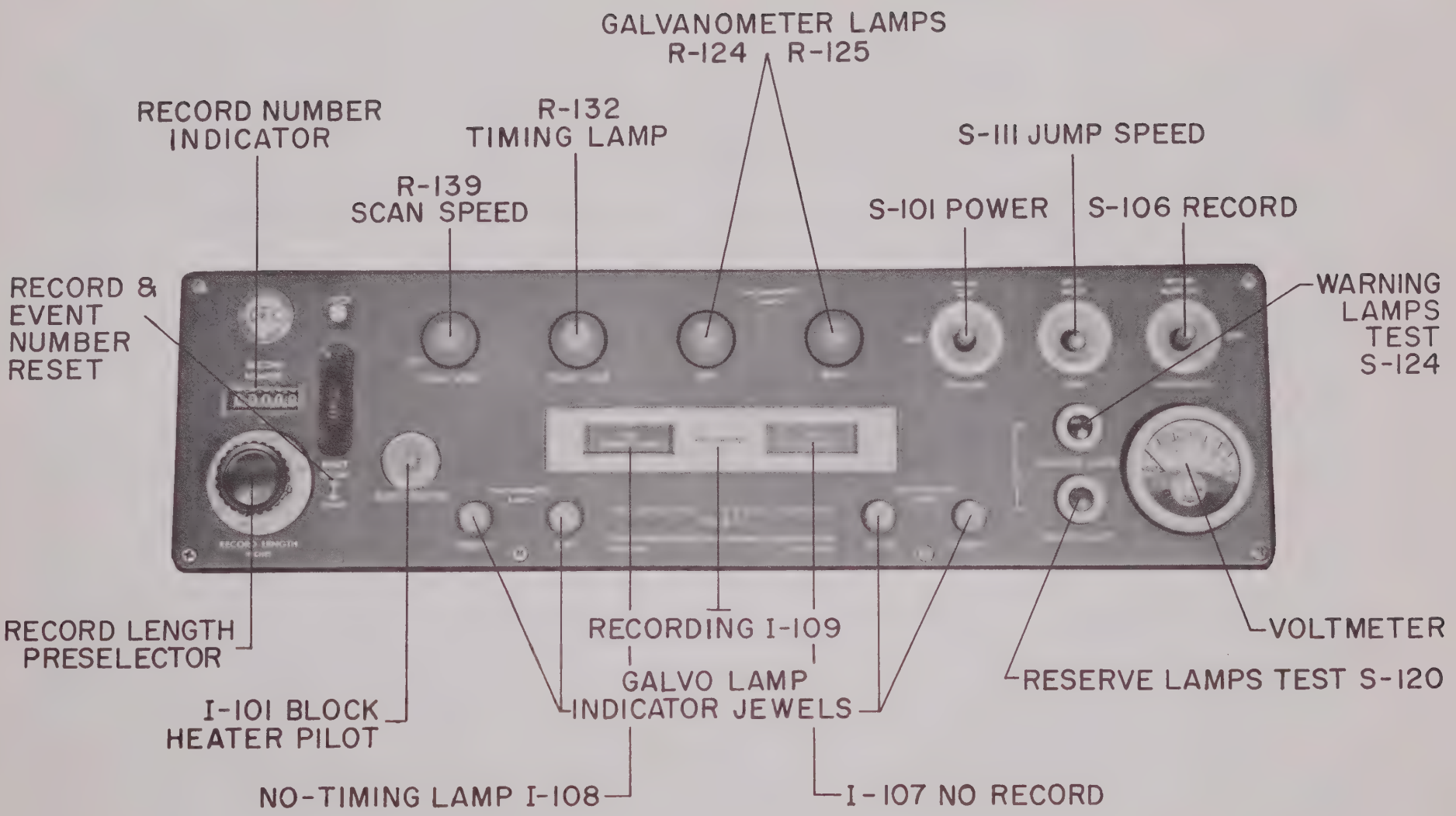
1. Control Panel (Fig. 1:02)

a. RECORD NUMBER

The number visible before a record is started indicates the number printed on the previous record. When a new record starts, the counter is automatically increased by one unit, and the new number, the instrument serial number, the event number, and a time arrow are photographed on the record at the end of the run by means of an automatic flashtube mechanism. The event number counter is not visible on the front panel. This count may be advanced and printed as described in Part X, paragraph A, 9.

b. RECORD LENGTH preselector

A record will start automatically when the RECORD switch is thrown to AUTOMATIC; a length of record corresponding in inches to the figure shown on the preselector will be run; the record will then stop automatically.



CONTROL PANEL

5-119P4
6-59 2061

FIG. 1:02

c. RESET and LOCK

Both the record number and event number, as well as the serial number of the oscillograph, are printed photographically on the record at any time either of the two circuits is energized.

Either of the two photographic counters may be zeroed by lifting the locking pin and turning the reset wheel on the left side of the control panel. The record number will be reset by moving the wheel up and away from the operator. The record number may be viewed at any time in the window to the left of the reset wheel. The event numbering counter may be zeroed by moving the reset wheel down or towards the operator. This number may not be viewed but the zero position will be indicated by a noticeable detent in the mechanism, and the arrow on the reset wheel will be up.

The directions for the reset wheel as described above apply for bench-operated 5-119's. If the oscillograph is vertically rack-mounted, the mechanism is still the same but the relative direction of rotation will be reversed.

d. SCAN SPEED (R-139)

The speed of the scanning motor is adjusted by this control to permit synchronization of various frequencies. It aids in viewing waveforms on the ground-glass viewing screen. When the knob is turned to OFF, the scanning motor does not operate.

e. TIMING LAMP (R-132)

This is a potentiometer control which, when depressed by finger pressure, closes switch S-121, thus applying recording voltage across the timing lamp, and also closes S-122 to apply the same voltage across the meter M-101. Voltage across the timing lamp can then be adjusted by turning the panel knob and reading the recording voltage level on the meter.

f. GALVANOMETER LAMPS, LEFT and RIGHT (R-124, R-125)

These potentiometer controls, when depressed, close switches S-112 and S-113 respectively, thus applying recording voltages across the left and/or right main recording lamps. The potentiometer controls also close switches S-114 and S-115 (see schematic) respectively, in either case applying the same voltage across the voltmeter that is applied to the lamp. Turning the potentiometer adjusts the lamp and indicated voltage. In case of main lamp failure, the adjusted potential will be applied to its reserve, as may be noted by depressing the RESERVE LAMPS test button.

g. POWER (S-101) This is a 3-position switch which:

(1) At OFF ... disconnects entire instrument from power source.

(2) At ON ... connects all the circuits of the oscillograph required for recording, and throws the galvanometer lamps on viewing voltage.

(3) At STANDBY ... brings galvanometer blocks up to normal operating temperature.

h. SPEED (S-111)

(1) HIGH position causes record to run at the higher speed indicated by the gear-change chart on the front of the oscillograph. This is ten times the lower speed. Speed may be switched from LOW to HIGH (or the reverse) during the course of a record.

(2) LOW position runs record at lower of two speeds shown on gear-change diagram.

i. RECORD (S-106)

(1) MANUAL position causes the record to run continuously until switch is returned manually to OFF.

(2) AUTOMATIC position causes a record of the length indicated by the RECORD LENGTH selector to be taken. The switch returns automatically to OFF.

j. BLOCK HEATERS (I-101)

Intermittent glow of pilot light corresponds to instantaneous state of the thermostat controlling the block heaters.

k. NO TIMING LAMP (I-108)

Indicates failure of timing lamp and warns against running of record when timing lines would not be recorded.

l. RECORDING (I-109)

Indicates that the recording bus has been energized, and that the instrument is recording.

m. NO RECORD (I-107)

When lighted, indicates that oscillograph is not ready to take a record because of:

(1) Burnout of either left or right main and reserve recording lamps.

(2) Recording medium stoppage due to:

(a) Jam

(b) Drive couple failure

(c) Omission of change gears

(d) Transmission failure

(e) Motor failure

(f) Paper or film supply exhausted

n. TEST buttons

(1) WARNING LAMPS (S-124)

Simulates all conditions of failure to determine whether the failure-indicating circuits are operating properly. When depressed, it causes NO TIMING LAMP, NO RECORD lamp, and BLOCK HEATER lamps to glow. The circuit actuated by this button is inoperative while a record is being run.

(2) RESERVE LAMPS (S-120)

Checks condition of reserve lamps. When depressed, causes RESERVE jewels at front of panel to glow if reserve galvanometer lamps are in operating condition.

o. GALVANOMETER LAMPS indicator jewels

These are an absolute indication of satisfactory lamps, since they are actuated by light conducted through lucite rods from the actual recording lamps. Left and right jewels indicate condition of main lamps; reserve jewels indicate condition of reserve lamps when TEST, RESERVE LAMPS button is depressed.

p. Voltmeter

This meter is employed for two purposes:

(1) In the a-c operated types, it indicates the internally rectified d-c voltage. The bracket at the upper range of the meter scale indicates the recommended limits of the internally rectified voltage for operating the oscillograph.

(2) When the timing lamp or galvanometer lamps controls are depressed, the meter indicates the voltage across the respective lamps. The bracket at the lower range of the scale indicates the recommended limits of lamp voltage. A higher voltage range is applied when the record switch is on high, thereby maintaining trace density at the higher writing speeds.

2. Top of Oscillograph (Fig. 1:03)

a. Scanning system reduction gears connect the scanning motor (B-104) with the polygon mirror (see Optical Schematic, Fig. 1:01). Gears may be adjusted for normal or high scanning speeds, as described in Part V.

b. Scanning lens control lever (refer to Part V, Operation)

(1) Vertical position is used for setting galvanometer fore-and-aft positions.

(2) Lower-rear position is used when scanning waveforms on the viewing screen and when making records.

3. Front of Oscillograph (Fig. 1:04)

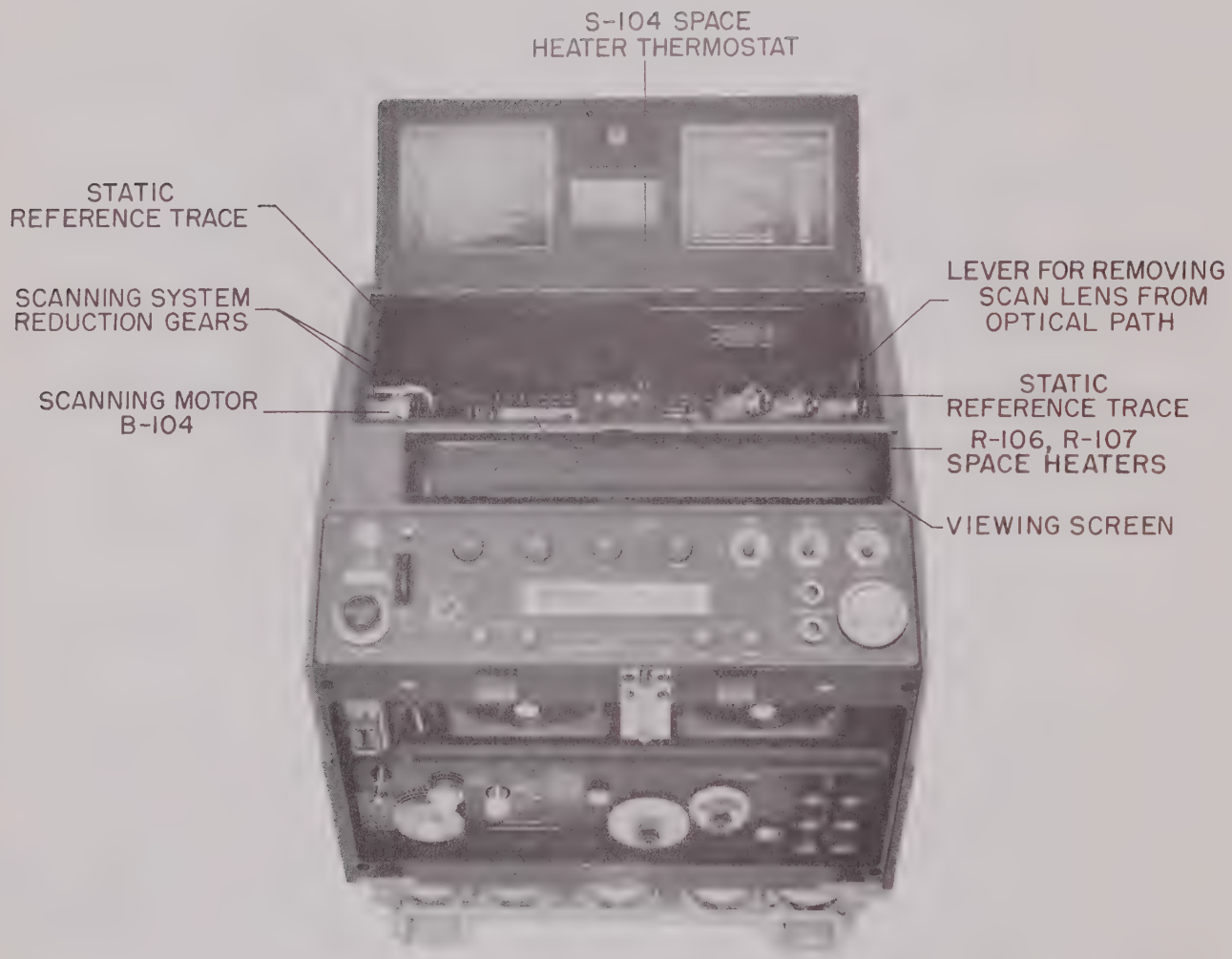
a. Record-numbering filter holder is removable for insertion of light reducing filters when film is being used for recording.

b. Main and reserve recording lamps on each side are identical and serve same function of illuminating half of the oscillograph's complete galvanometer complement. Internal circuitry automatically connects the reserve when the main lamp on either side fails. This prevents loss of record. Lamps are pre-focused, and the filament is in position for optimum lighting of galvanometers when installed. Covers must be secured over lamps before operation of oscillograph.

c. Spare change gears and external transmission gearing make possible a range of record speeds from 0.16 inch to 160 inches per second. Some instruments have a record speed range from 0.10 inch to 100 inches per second. (Refer to Part VI for details.)

d. Timing system cover can be removed by loosening two holding screws. Timing lamp can be changed or positioned; timing lines can be adjusted to either full-record width or edge designations; and 1/100th-second timing lines can be eliminated after removing this cover. (See Part VI.)

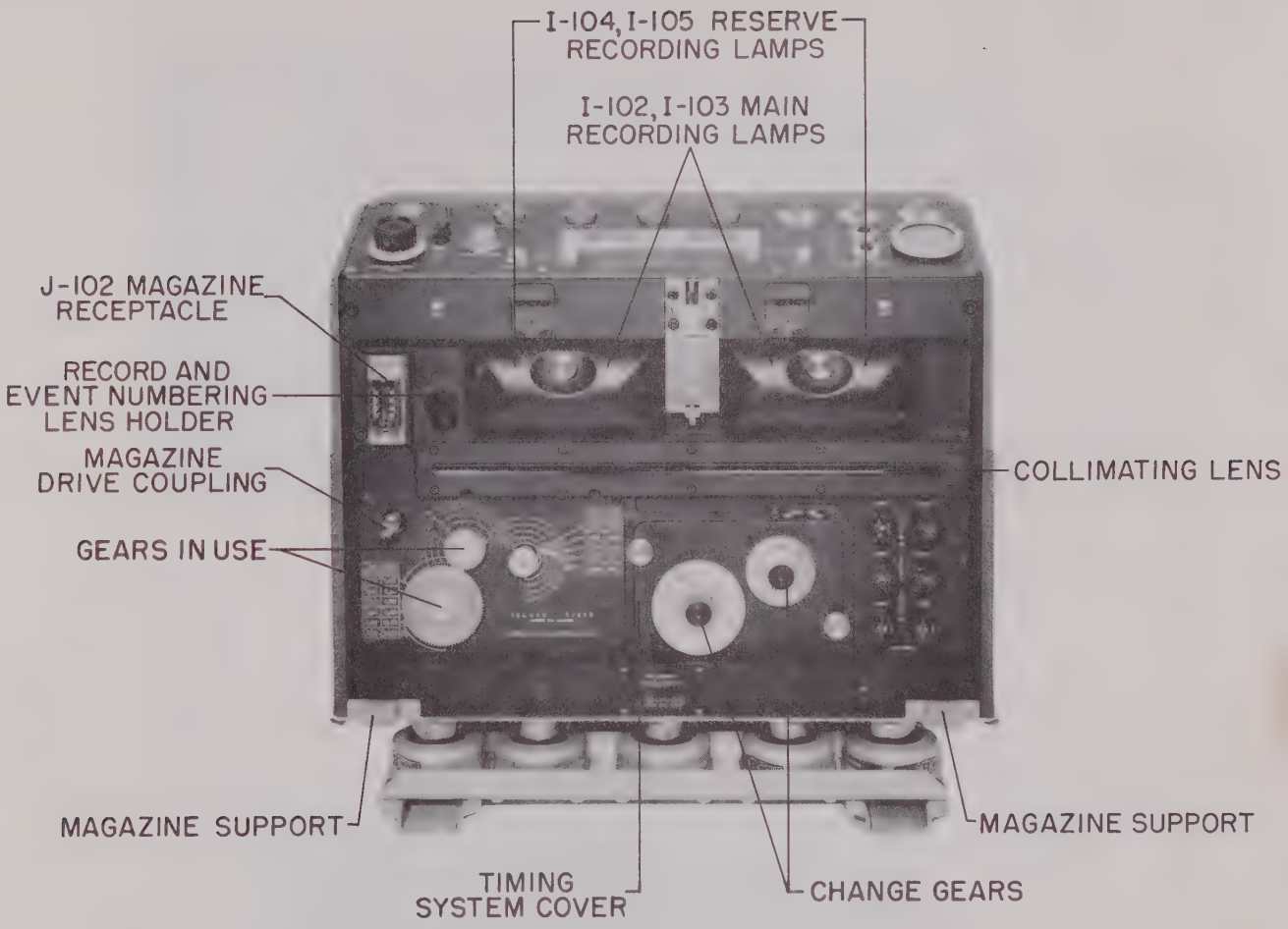
e. Magazine-drive coupling and connector J-102 are automatically and correctly engaged when magazine is placed on magazine supports and locked in place with its handle.



TOP VIEW, GALVANOMETER COMPARTMENT OPEN

5-119P4
6-59 2061

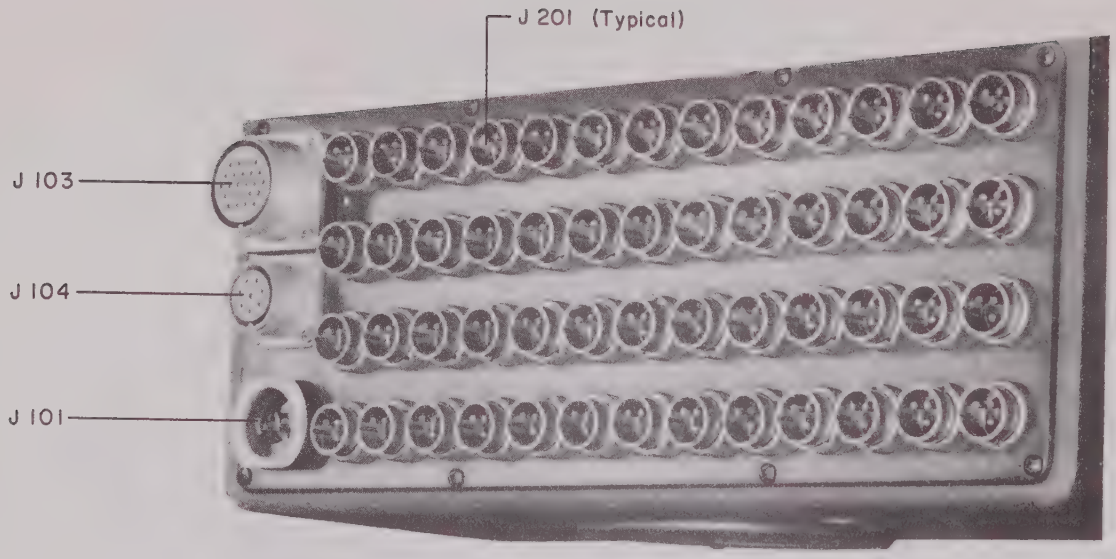
FIG. 1:03



FRONT, MAGAZINE REMOVED

FIG. 1:04

5-119P4
6-59 2061



REAR DECK - TOP VIEW
FIG. 1:05

RECORD MAGAZINE, TYPE 5-006A
FIG. 1:06

5-119P4
6-59 2061

4. Rear Deck of Oscillograph (Fig. 1:05)

a. Galvanometer input connectors are numbered to correspond to the figures seen from above through the galvanometer-access door. The receptacles are Cannon Electric Type XL-3-11. A complete set of mating plugs is furnished with the instrument. Pin connections are as follows:

Pin	Wire Color	To
1	White	Galvanometer rear connection
2	Black	Galvanometer top connection
3	Black tubing	Bus to ground

The polarity is such that a positive potential applied to pin 2 (galvanometer top post) results in deflection to the left on the viewing screen. Factors that determine direction of trace deflection on the screen are magnet block polarity and polarity of potential applied to the galvanometer top post. Deflection on the resultant developed oscillogram depends also on the direction of paper travel during recording (Fig. 1:08).

The following convention is adhered to in all CEC oscillographs. A positive signal applied to the galvanometer top connection will result in upward displacement of the trace on the developed original record if it is positioned so time progresses toward the right. This is conventional in curve drawing, i. e., when the oscillogram is face up on a table, the events which took place first are recorded at the left end and the later events toward the right (Fig. 1:08).

b. The J-101 power-input connector has a pin arrangement used by CEC for a-c models only. Power input cable is furnished.

c. Receptacles J-103 and J-104 are used with the Type 11-108 Remote Control Unit.

5. The Catalog No. 5-006A Record Magazine (Fig. 1:06)

a. This is the standard magazine furnished with the 5-119P4 Oscillograph. Of integral design, it contains both feed and takeup rolls and is completely light-tight when removed from the oscillograph. It may be handled freely in bright light without exposing or fogging of records. The magazine lock also serves as a convenient carrying handle.

b. Standard recording material is 12 inches wide, furnished in rolls containing 250 to 475 feet of paper. Different materials available are described in Part IV. Narrower material is available in widths of 5, 6, 7, 8, and 10 inches on special order, for use if only a few traces are to be recorded. Holes have been drilled in the shaft to hold the retaining flanges at any of these widths. Special order will usually involve delayed delivery. Each such order should mention specification number 28 in order to assure the proper core size and method of record winding for the 5-119P4 Oscillograph.

c. The length of remaining, unexposed material on the feed spool is indicated on the UNEXPOSED SUPPLY indicator. Electrical connections to operate the oscillograph warning circuits and the remote control unexposed supply indicator (when used) are made automatically when the magazine is attached.

D. PERFORMANCE SPECIFICATIONS

1. Recording

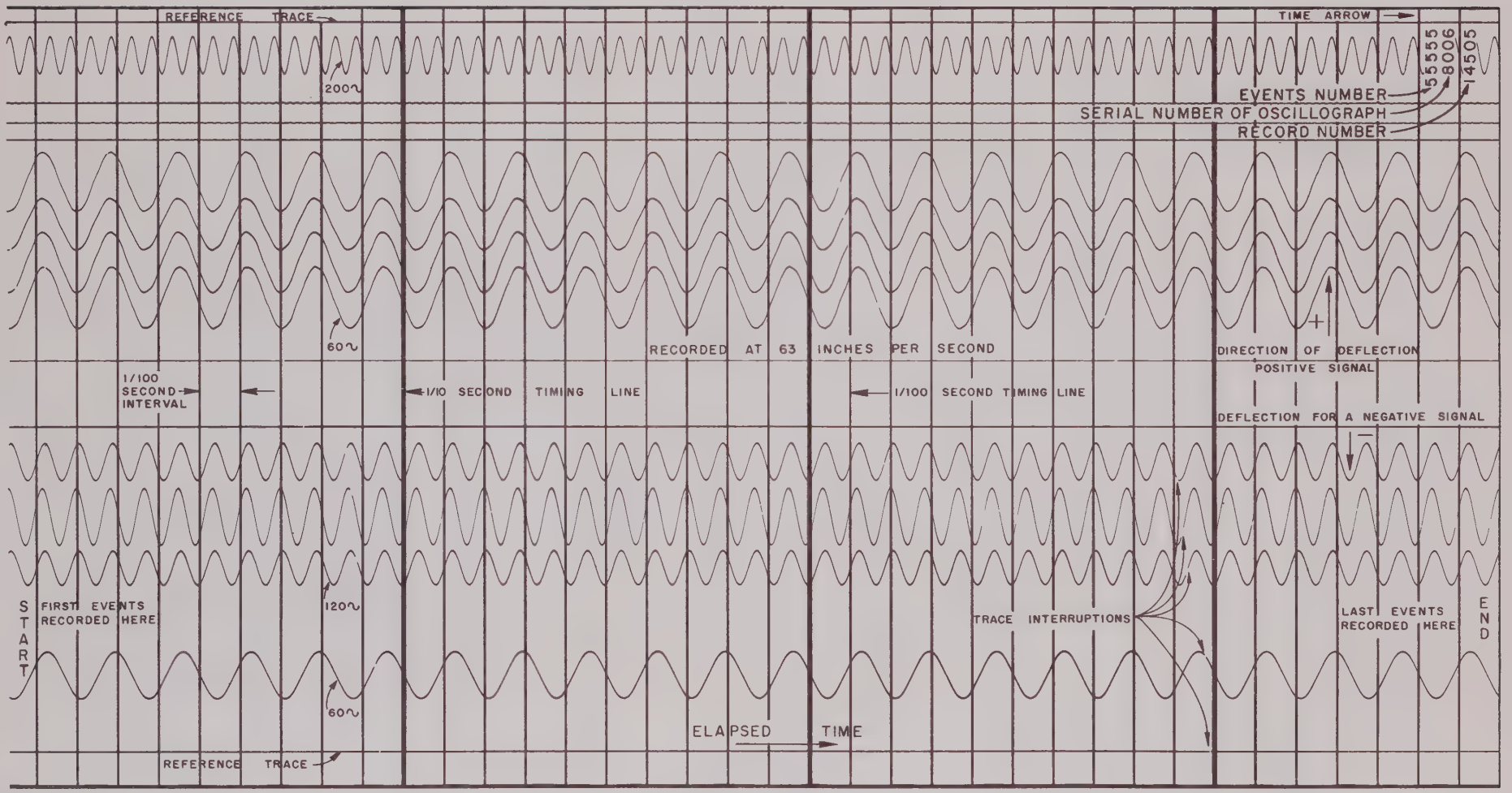
a. Active data channels: 36 or 50

b. Reference traces: 36-channel oscillograph - 4 static reference traces, 1 dynamic reference trace.
50-channel oscillograph - 2 static reference traces.

REAR VIEW

FIG. 1:07

5-119P4
6-59 2061



5-119P4
6-59 2061

SAMPLE RECORD
FIG. 1:08

c. Record speeds: 16 speeds over a range of .16 to 160 or 0.1 to 100 inches per second.

d. Magnet blocks: Two Alnico V blocks heated and thermostatically controlled at 100°F.

e. Optical arm: 11.5 inches

f. Frequency response: 0-5000 cycles per second.

g. Timing lines: Slotted disc timing provides 0.1-second or 0.01-second lines with every tenth line emphasized, full width of record or 3/4-inch wide at each margin.

h. Galvanometers: Type 7-300 series is used.

i. Record widths: 12 inches (standard). Narrower widths are accommodated in the 5-006A Magazine and 5-032 Magazine.

j. Record lengths: Dependent upon magazine used.
5-006A - 475 feet maximum
5-032 - 475 feet maximum
5-036B - 400 feet maximum

k. Trace identifier: Sequentially interrupts each trace with a 1/32-inch gap. Gaps occur at 12-inch intervals.

l. Jump-speed switch: 10 to 1 change-up or down-within the speed range of the oscillograph. Galvanometer illumination is automatically raised or lowered.

m. Record identification: A five-digit record number, an arrow indicating the direction of increasing time, and the oscillograph serial number are photographed simultaneously and automatically at the end of each record. A duplicate of the record number is visible on the control panel. Both may be mechanically reset to zero at any time.

n. Event numbering: A five-digit event number counter may be actuated by an external contact closure as often as twice per second, and photographed on the record. This counter may be reset to zero at any time.

o. Automatic record length: A control is provided to produce records of predetermined length over a range of 10 to 100 inches.

p. Polygon scanning: A rotating mirror permits synchronization of essentially sinusoidal signals through a frequency range of 10 to 500 cps on the viewing screen.

q. Spot setting: Provision is made to use the optical components of the scanning assembly to set the vertical and horizontal position of the galvanometer traces.

r. Galvanometer illumination: Each galvanometer bank has its own light source with automatic switch-over to a reserve lamp in the case of failure.

s. Controls and indicators:

(1) Operator controls

(a) Power switch - ON, OFF, STANDBY

(b) Record switch - MANUAL, OFF, AUTOMATIC

(c) Jump-speed switch - HIGH, LOW

(d) Galvanometer lamp intensity controls - one for the LEFT bank, one for the RIGHT bank.

(e) Scan speed rheostat control with OFF position.

(f) Automatic record length control preselects record run.

(g) Warning lamps test button checks failure indicators.

(h) Record and event number reset knob.

(i) Reserve lamps test button.

(2) Operator indicators:

(a) RECORDING

(b) NO RECORD

(c) NO TIMING

(d) Functioning of galvanometer lamps

(e) Functioning of block heaters

(f) Record number

(g) Voltmeter

2. Electrical

a. Power consumption: 135 watts, STANDBY
350 watts, POWER ON
600 watts, MAXIMUM SPEED

b. Voltage requirement: 105 to 125 volts, 60-cycle, single phase.

c. Galvanometer input: All inputs are made through individual receptacles located on the rear deck of the oscillograph. Connectors of the Cannon XL-3-11 type are provided for each active and dynamic trace.

3. Physical

a. Dimensions: Height, with vibration isolator - 14"
Width, with 5-006A, or 5-036B Magazines installed - 15 1/2"
Width, with 5-032 Magazine installed - 17"
Length, with 5-006A Magazine installed - 27 11/16"
Length, with 5-036B Magazine installed - 36 1/2"
Length, with 5-032 Magazine installed - 28 11/16"
Length, with 5-036B Magazine installed and 5-046 Takeup Reel extended horizontally - 61 1/2"
(See installation instructions)

b. Approximate weight: With loaded 5-006A Magazine installed - 145 lbs.
With loaded 5-032 Magazine installed - 185 lbs.
With loaded 5-036B Magazine installed - 175 lbs.
With loaded 5-036B Magazine and 5-046 Takeup Reel installed - 200 lbs.

4. Environmental

a. Specifications applying to 5-119P4 Oscillograph with 5-006A or 5-032 Magazines attached:

(1) Altitude: 0-60,000 feet.

(2) Temperature: (Magnet block) Fluid-damped galvanometer specifications apply at 100°F. The galvanometer block heaters will maintain this temperature if the oscillograph ambient is between 0°F and 90°F.
(Oscillograph) Operable from 0°F to 150°F.

(3) Atmosphere: Average sea coast corrosion conditions.

(4) Acceleration with vibration isolator attached: Vertically downward - 10 g's
Vertically upward - 2 g's
Any horizontal direction - 5 g's

(5) Vibration forces with vibration isolator attached: 0.03 inches double amplitude in any direction through frequencies of 10 to 60 cps.

(6) Shock forces (non-operating): 15 g's in any direction for a duration of 11 milliseconds with vibration isolator attached.

PART II

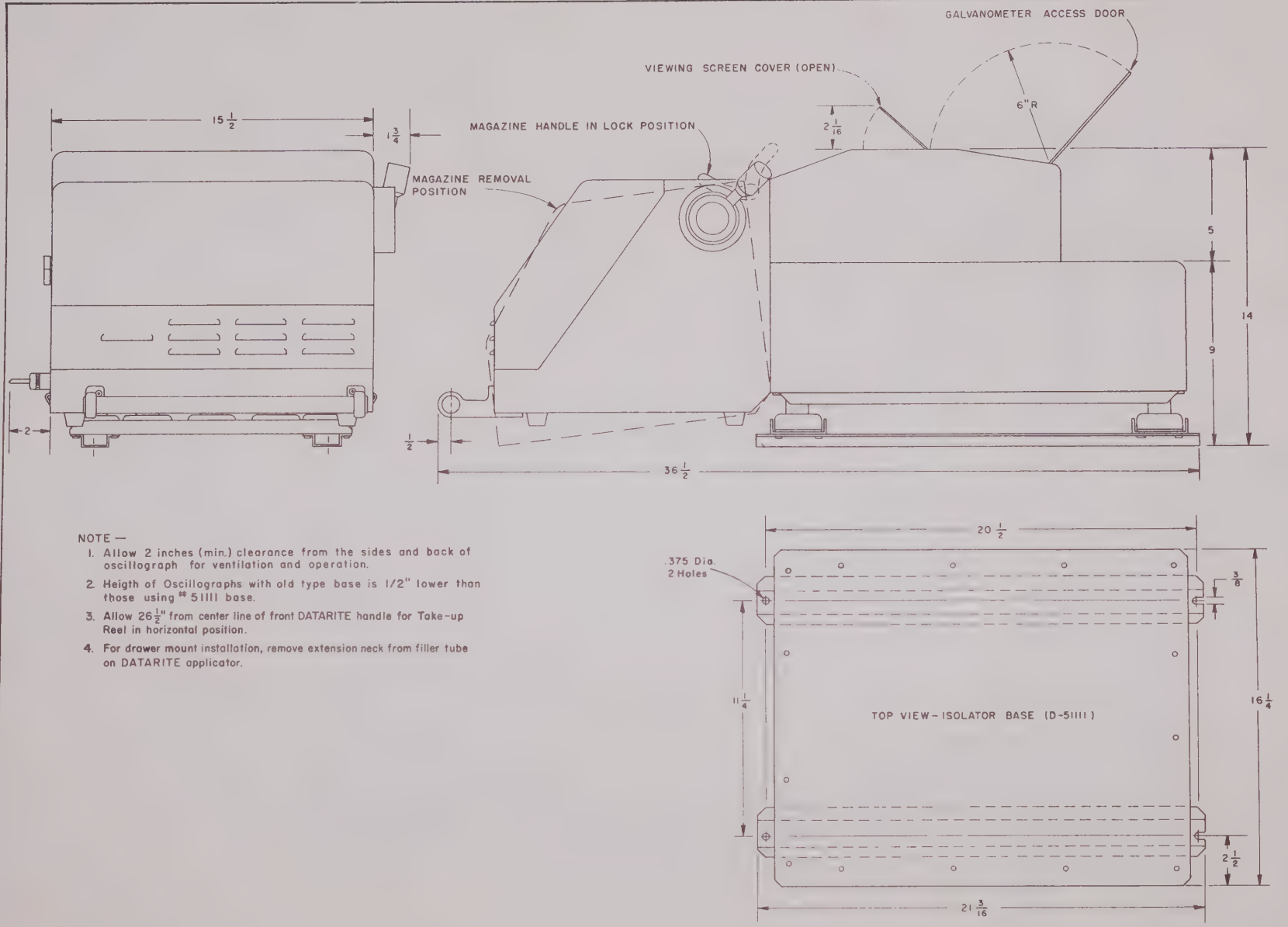
INSTALLATION

Included in this section are dimensional descriptions for mounting the 5-119P4 Oscillograph with the following: 5-006A Magazine, 5-036B DATARITE, 5-017 Vertical Rack Mounting, and 156112 Horizontal Drawer Mounting.

Clearance must be allowed at the rear of the unit for cabling and ventilation; clearance above the unit for internal adjustment through the access door; and clearance in front for installation or removal of the magazine.

PACKING LIST

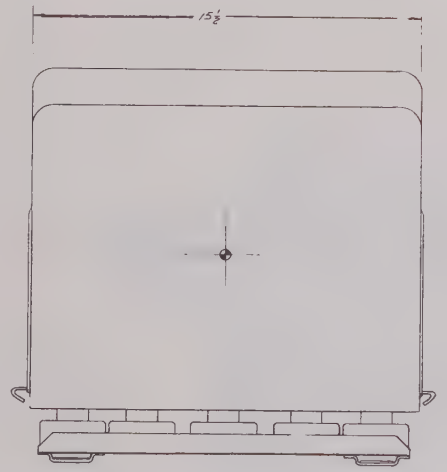
1	5-119P4-36 or -50	Recording Oscillograph (less magazine)
1		Magazine (type specified)
1	30155	Cover, Protective
2	32488-2 or -3	Case, Galvanometer
1	Set	Accessories attached to oscillograph, including:
1	16656-32	Fuse, 2 amp
1	16656-33	Fuse, 3 amp
1	16656-35	Fuse, 10 amp
1	21606	Galvanometer Lateral Adjustment Wrench
1	31736	Galvanometer Tilt Wrench
1	31333	Galvanometer Lifting Tool
3	21642	Illuminator, Recording
1	49636	Cable Assembly, a-c power
1	34620-2061	Operation and Maintenance Manual
1	34711	Lamp Removal Tool
1	32932P4	Kit of Accessories and Spare Parts, including:
37 or 52	8792	Connector, 3 contact
3	19785-2	Illuminator, Pilot
1	19785-5	Illuminator, Pilot
1	30748	Illuminator, Meter
1	70075-10	Clamp, Connector
1	70075-16	Clamp, Connector
1	38108-1	Plug, Connector, 8 pin
1	38124-1	Plug, Connector, 24 pin
1	30959-3E	Card, Galvanometer Data
1	30959-4E	Card, Galvanometer Data

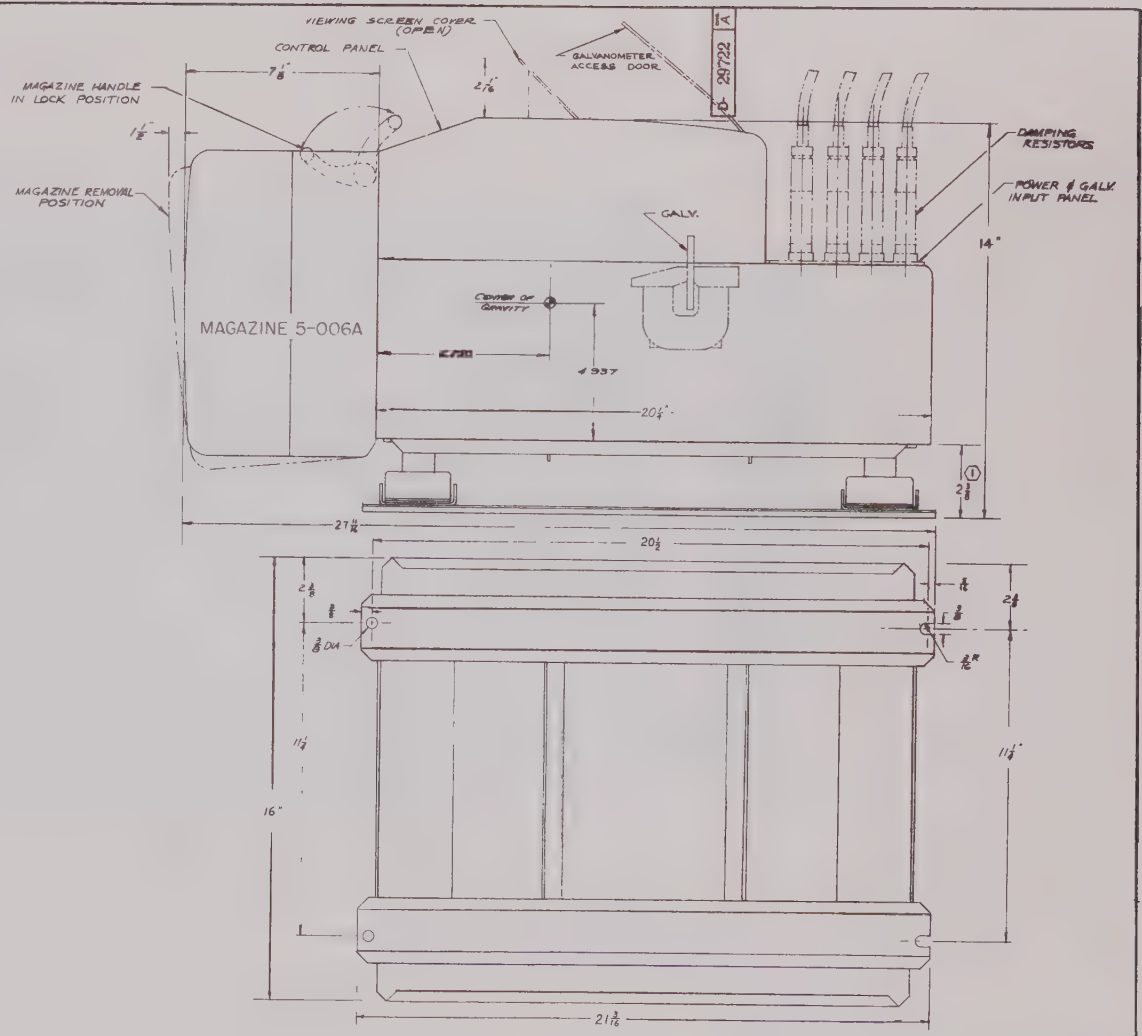


NOTE —

1. Allow 2 inches (min.) clearance from the sides and back of oscillograph for ventilation and operation.
2. Heigth of Oscillographs with old type base is 1/2" lower than those using # 51111 base.
3. Allow 26 1/2" from center line of front DATARITE handle for Take-up Reel in horizontal position.
4. For drawer mount installation, remove extension neck from filler tube on DATARITE applicator.

INSTALLATION 5-119 RECORDING OSCILLOGRAPH WITH DATARITE MAGAZINE
FIG. 2:01





APPROXIMATE WEIGHT 145 POUNDS

① SHOCK MOUNT FREE HIGHT 2 3/8
LOADED HIGHT: 2 1/8
BOTTOMED HIGHT: 2 3/32

NOTE

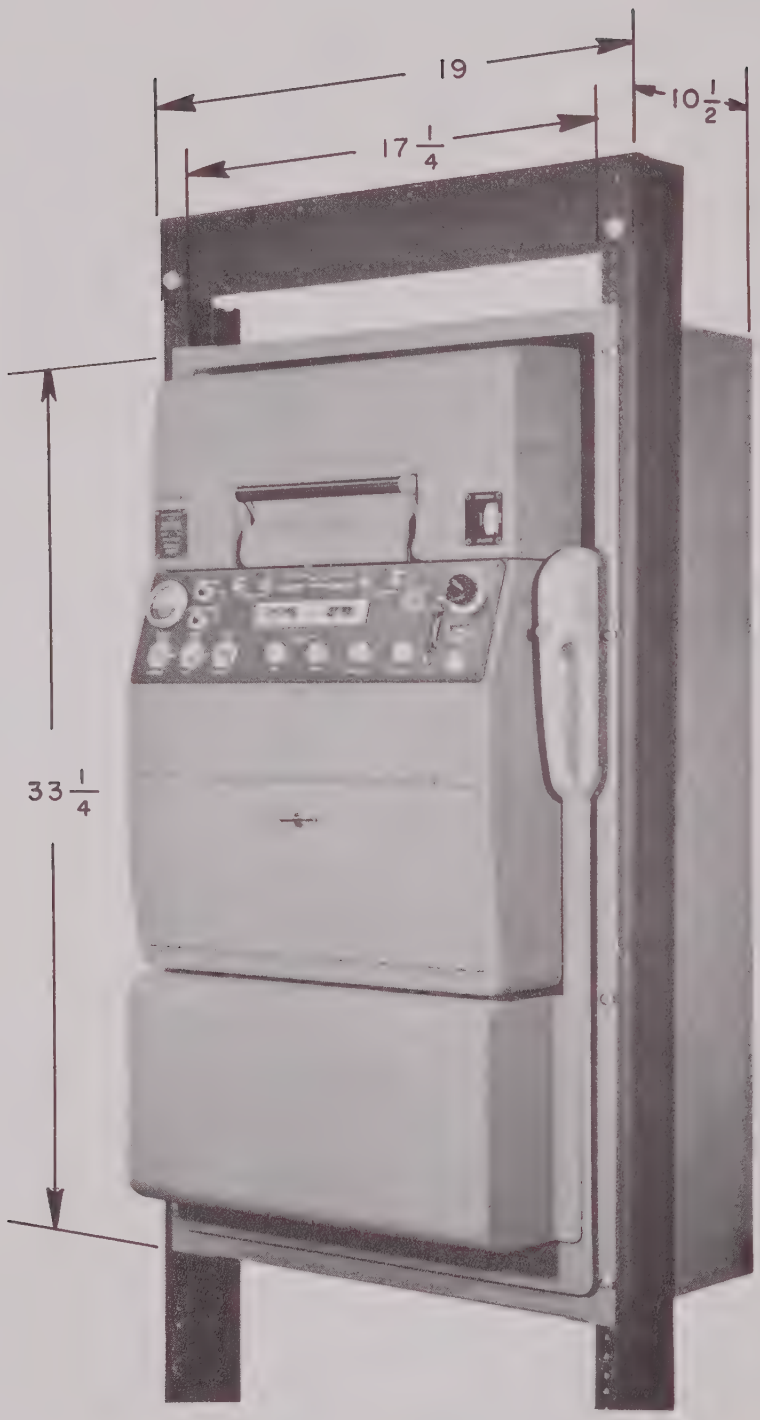
CONSOLIDATED ELECTRODYNAMICS CORPORATION, PASADENA CALIFORNIA

5-119P4 RECORDING OSCILLOGRAPH

INSTALLATION DRAWING

LOT 14 | 29772A (REF)

FIG. 2:02

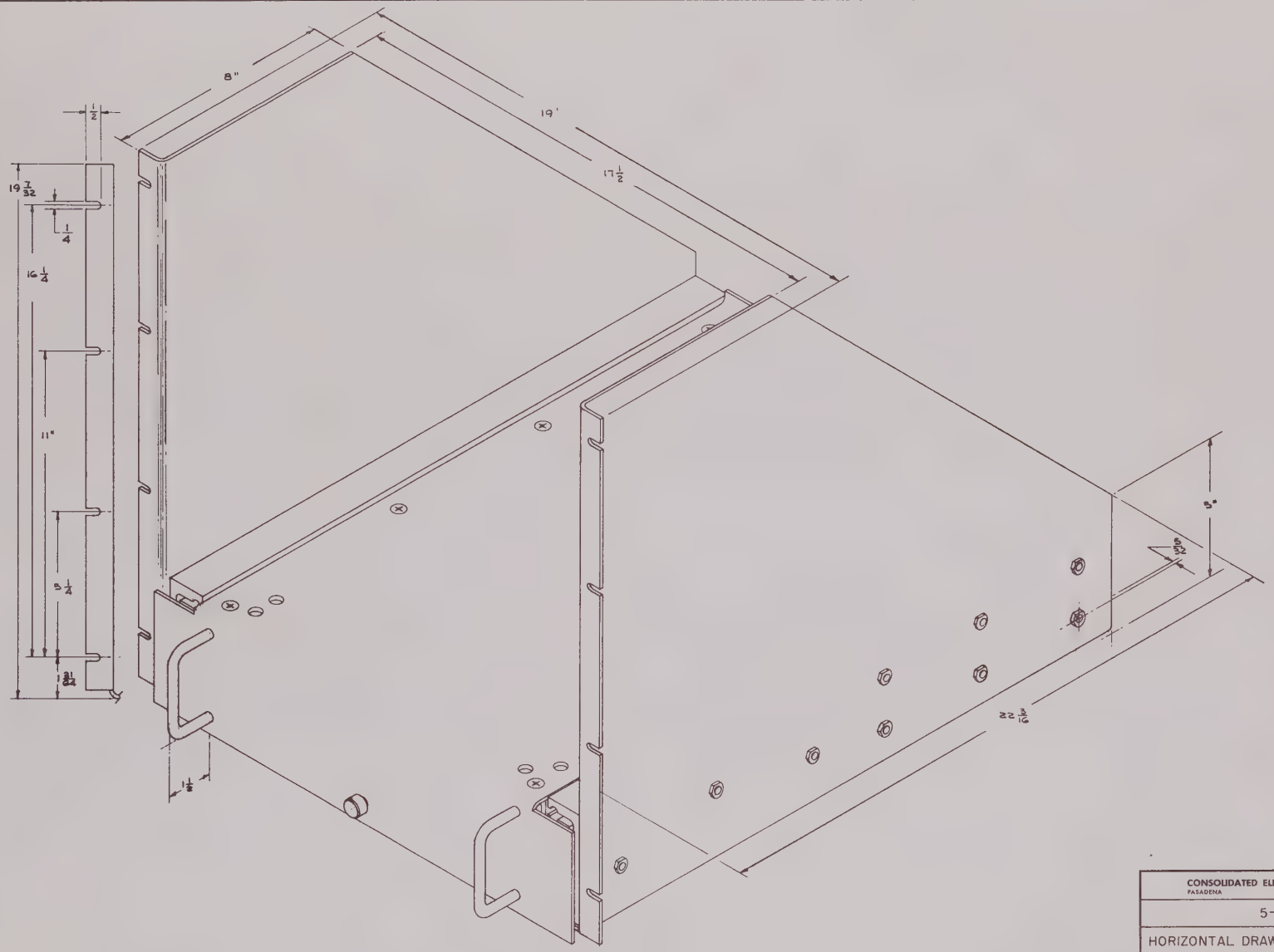


RACK MOUNTING 5-017

Built to R.T.M.A. standard dimensions (Stand not included)

5-119P4
6-59 2061

FIG. 2:03



CONSOLIDATED ELECTRODYNAMICS CORPORATION, PASADENA CALIFORNIA	
5-119P4	
HORIZONTAL DRAWER MT. INSTALLATION DWG.	
	156112 (REF)

LOT 14

FIG. 2:04

PART III

GALVANOMETERS

The D'Arsonval-type galvanometer is one of the most sensitive current measuring devices available. In its laboratory form it is large, slow, and easily disturbed by any slight vibration. In the CEC laboratories, over a period of twenty years, extensive design effort has been directed to the development of a galvanometer which satisfies the environmental and performance requirements of flight test and other experimental applications. Out of these efforts has resulted an instrument that is outstanding in regard to physical size (miniature), performance (sensitivity, linearity, and natural frequency), and environmental adaptability (shock, vibration, temperature, and pressure).

Because sensing devices (transducers) must be designed for the utmost sensitivity, linearity, and other characteristics difficult to achieve, they cannot usually be made with outputs which fit the exact requirements of any galvanometer input. For satisfactory performance, impedance-matching, damping, amplifying, and/or attenuating must be carefully considered.

An addition to this section has an extended discussion of galvanometer theory together with the various input requirements.

The oscillograph, in the final analysis, is only an instrument to transform the response of a series of galvanometers into permanent, time-related records. The galvanometers, therefore, can be regarded as the heart of the instrument, and a full understanding of their use and applications will help the operator to obtain optimum results. This section is only a preliminary treatment of the subject.

The 5-119P4 Oscillograph has a thermostatically controlled magnet block. The temperature is regulated at 100°F. The galvanometers are specifically designed to withstand the environments which the oscillograph may encounter.

A. GALVANOMETER SELECTION

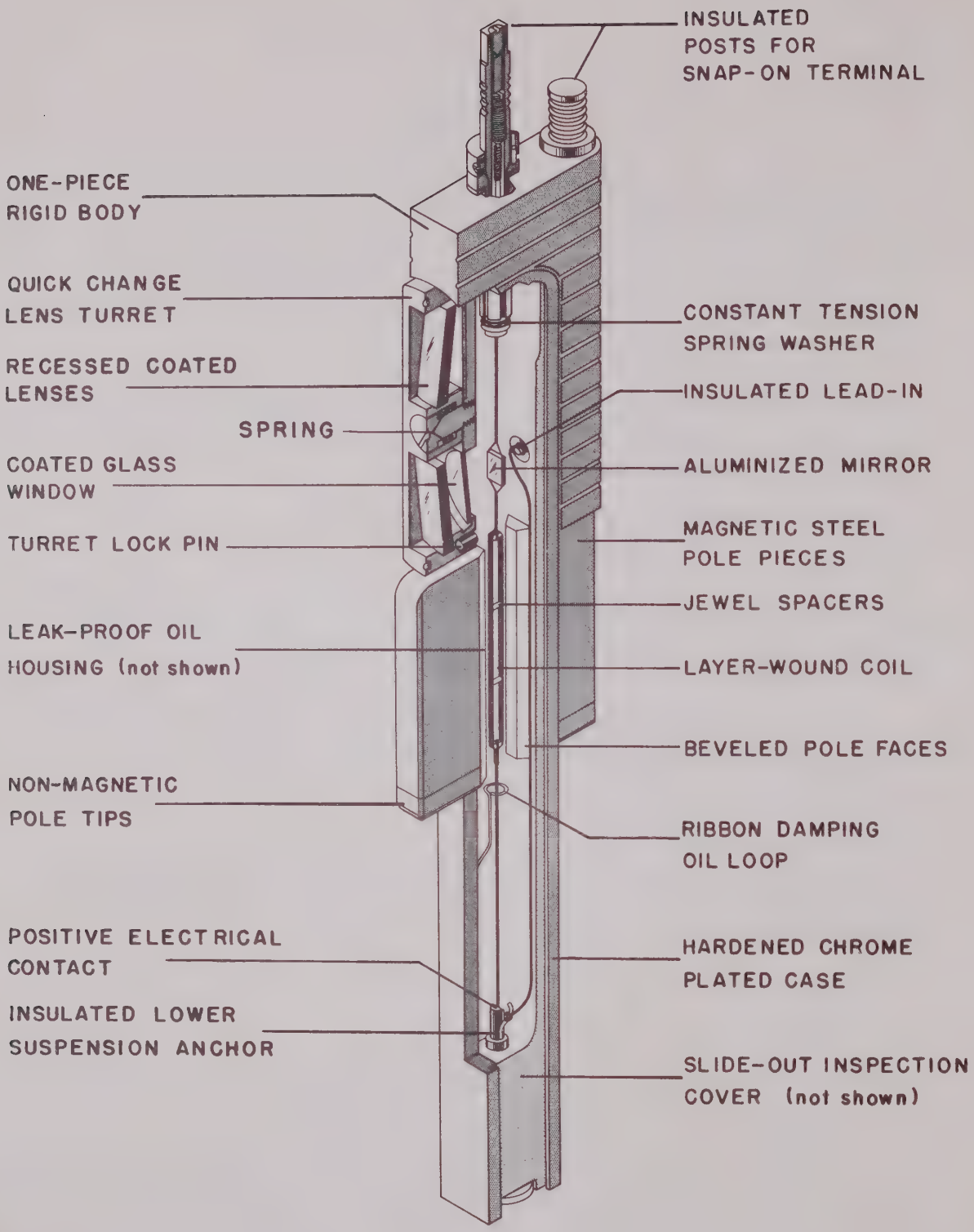
In most cases, galvanometers for at least the initial series of tests will have been ordered and received with the oscillograph. Additional galvanometers may be selected, as were those of the original complement, on the basis of:

1. The characteristics of the phenomenon to be recorded.
2. The frequency range and sensitivity of the galvanometer.
3. The characteristics of the circuit driving the galvanometer.

Characteristics of galvanometers are listed in the table, Fig. 3:06.

A 7-004 Dynamic Reference Trace is included in each 36-channel oscillograph for event or timing marks. This galvanometer is located adjacent to Channel #1. It is fluid damped and has the following characteristics:

Flat frequency range	0 - 2000 cps
Resonant frequency	3400 cps
Undamped d-c sensitivity (11.5-inch optical arm)	28.0 milliamps/inch
Terminal resistance	56 ohms
Nominal galvanometer voltage sensitivity (11.5-inch optical arm)	1.57 volts/inch
Fluid damping	68% of critical damping
Safe current	100 milliamperes



TYPE 7-300 GALVANOMETER

FIG. 3:01

5-119P4
6-59 2061

B. DIRECTION OF GALVANOMETER SPOT DEFLECTION

The black signal wire goes to the galvanometer top post; this should be the positive lead. The wire to the rear post (negative connection) is white.

The polarity is such that a positive potential applied to the galvanometer top connection results in deflection to the left on the spot setting screen. The factors that determine trace deflection on the screen are magnet block polarity and positive or negative potential applied to the galvanometer top post. (Positive to the top post is always assumed.) Zero location on the record depends also on a third factor, direction of travel of paper during recording. The following convention is adhered to in all CEC oscillographs. Positive signal applied to the galvanometer top post will result in upward deflection of the trace on the developed original record if it is positioned so time progresses toward the right.

C. DAMPING

Damping can only be considered in connection with a specific galvanometer and its driving source. The source impedance must mate the resistance requirement of the galvanometer if proper damping is to be achieved.

If other than CEC systems are employed to drive the galvanometers, a thorough evaluation of the circuit must be made to be sure that external damping resistance (i.e., the resistance other than that measured across the galvanometer terminals) is that value shown in the galvanometer table. If source impedance is not correct, additional provision for damping must be inserted in the circuit. Details for calculating the value are given in Technical Paper 1582 at the end of the section.

A convenient method for incorporating such resistance is the Plug-In Damping Resistor shown in Fig. 10:02. Available in either series or shunt form, these units mate with both galvanometer-input cable and receptacle to insert proper resistance directly in the galvanometer circuit.

D. GALVANOMETER MARKINGS

1. Color Coding

As an aid to identification, the last two digits in the type number of all CEC galvanometers are color-coded according to the standard RETMA system. Markings will be found on both the back terminal post and the front terminal post, the numbers being read in sequence from back to front. Thus, a 7-326 Galvanometer would bear a red dot on the back post for the number 2, and a blue dot on the front post for the number 6. In addition, the side of the galvanometer case is engraved "7-326".

2. Lens Identification

Each galvanometer has two recessed, coated lenses, each for a different optical arm (focal distance). These lenses are mounted in a rotating turret located immediately in front of the galvanometer mirror. This turret is under the positive action of a spring and an index pin which hold it firmly in place and against the galvanometer body. To change lenses, merely grasp the turret between the thumb and index finger, pull out gently, rotate 180° and release. The pin centers the lens before the mirror, properly aligning it ready for immediate use without further adjustment. Two very small colored dots located on the outside margins of the metal lens frame denote the optical arm of each lens. The lens marked by the red dot is for an optical arm of 11.5 inches, and the lens marked with the yellow dot is for an optical arm of 7.5 inches. The lens with the red dot should be used with the 5-119P4 Oscillograph. Be certain that the lens with the red dot is in the down position and hence in front of the mirror. The mirror itself is flat.

3. Dummy Galvanometers

If it is desirable to install fewer than the full number of galvanometers in a block and essential to maintain sensitivity damping characteristics, dummy galvanometers should be installed. A dummy is a

GALVANOMETER INSTALLATION OR REMOVAL WITH LIFTING TOOL
(TYPICAL BLOCK & TOOLS)

FIG. 3:02

INSTALLATION OR REMOVAL OF SIGNAL LEAD CLIP

THE CLIP SHOULD BE IN PLACE BEFORE COMPLETION OF THE LATERAL AND VERTICAL (TILT) ADJUSTMENTS

FIG. 3:03

LATERAL ADJUSTMENT OF GALVANOMETER MIRROR

FIG. 3:04

TILT ADJUSTMENT WITH CAM END OF ADJUSTING TOOL

FIG. 3:05

galvanometer case with no suspension, but with standard pole pieces and pole spacing, maintaining the flux density constant throughout the magnet block.

E. GALVANOMETER INSTALLATION, CONNECTION, ADJUSTMENT, AND REMOVAL

Galvanometers are precision instruments and, while they are designed to withstand rigorous test conditions, damage may result from excessively rough or careless handling. Avoid touching lenses, for finger marks will impair recording quality and eventually harm the optical surface. Cleaning, when necessary, can be accomplished simply by moistening the surface with the breath and wiping it with lintless cloth or lens tissue. Do not use solvents.

1. Galvanometer Installation

a. The mirrors of the galvanometers are flat and the reflected light is focused through a lens. Although the lens turret contains two lenses, only the one having a red dot adjacent to it is used in the 5-119P4 Oscillograph. Before installing any galvanometer, be certain that the lens having an adjacent red dot is in the lower position, i.e., in front of the opening in the galvanometer case. When the turret is in this position, a yellow dot will be seen at its top.

b. Galvanometer pole pieces are attracted to the projections between the slots of the block top plate rather than to the slots themselves. This force must be anticipated by bracing the hand firmly against the oscillograph case to prevent the galvanometer from forcibly snapping onto the magnet block. If two or more adjacent galvanometers are being installed, each must be worked over and into its slot with fingers.

c. After the galvanometer is started into its proper slot, release the lifting tool. Avoid striking the lens.

d. Push the galvanometer down into place against the stop by pressure on the rear terminal post. This positions the element correctly for height without unduly straining the lens mount.

e. If any dummy galvanometers are to be used, they should be placed in the magnet block first. (The lifting tool is not required for this.) One edge of these is painted; this edge should be placed facing the front of the oscillograph.

2. Galvanometer Connection

Signal leads are brought through an individual, snap-on terminal block to each galvanometer. Both top and rear connections are made through this block, the black (positive) wire connecting to the top post and the white (negative) connecting to the rear. Input connector pin connections are shown on the cable schematic.

3. Galvanometer Adjustment

The mirror behind the lens should be adjusted to a straight, forward position, i.e., to the position where light reflects straight out of the galvanometer case. Use the socket type galvanometer-adjusting tool to rotate the top post carefully and bring the mirror to the front. Rotation should be in the direction requiring the least turning, and particular care should be taken to avoid straining the limiting stops.

a. Lateral adjustment

(1) Have the SCAN SPEED switch off, the POWER switch on.

GALVANOMETER SPECIFICATIONS—TYPE 7-300 SERIES

STANDARD GALVANOMETERS

Type 7-300	External Damping Resistance Required (1)	Undamped Natural Frequency	Flat (±5%) Frequency Range	Terminal Resistance (±10%)	Sensitivity At 11.5 Inch Optical Arm				Static Balance (3)		Maximum Safe Current	Unit Price (*4)
					Undamped d-c Sensitivity		System Voltage Sensitivity (2)		Standard	Special		
	Ohms	cps	cps	Ohms					in/g	in/g	ma	
Magnetically Damped					μa/in	in/μa	mv/in	in/mv				
7-325	350	18.5	0-11	18	7.94	0.125	2.92	0.343	0.050	0.025	15	$145.00*
7-339	350	50	0-30	30	4.61	0.217	1.75	0.572	0.032	0.016	15	160.00*
7-315	350	100	0-60	33	12.2	0.0820	4.67	0.214	0.016	0.008	15	175.00*
7-312	350	100	0-60	40	29.9	0.0334	11.7	0.0858	0.016	0.008	25	140.00*
7-318	180	150	0-90	26	30.6	0.0327	6.29	0.159	0.012	0.006	25	160.00*
7-338	120	210	0-125	25	57.8	0.0173	8.40	0.119	0.012	0.006	50	160.00*
7-324	83	300	0-180	43	265.	0.00377	33.3	0.030	0.012	0.006	50	125.00*
7-319	25	585	0-350	26	426.	0.00115	21.7	0.046	0.012	0.006	50	140.00*
Fluid Damped					ma/in	in/ma	v/in	in/v				
7-323	1000	1000	0-600	26	2.50	0.400	2.56	0.390	0.008		100	140.00
7-320	200	1000	0-600	26	2.30	0.434	0.521	1.92	0.008		100	140.00
7-316	200	2000	0-1200	25	9.17	0.109	2.05	0.487	0.005		100	140.00
7-317	28	3700	0-2200	25	40.6	0.0246	2.16	0.464	0.005		100	140.00
7-326	55	5000	0-3000	53	31.8	0.0314	3.44	0.291	0.005		100	160.00

HIGH PERFORMANCE GALVANOMETERS

Magnetically Damped					μa/in	in/μa	mv/in	in/mv				
7-349	350	10	0-6	130	1.62	0.617	0.778	1.286	0.026		15	215.00
7-351	350	20	0-12	33	2.66	0.375	1.02	0.982	0.016		15	185.00
7-341	350	100	0-60	47	6.12	0.163	2.43	0.411	0.012		10	180.00
7-342	350	225	0-135	86	10.7	0.0935	4.67	0.214	0.008		15	195.00
7-346	350	320	0-190	60	26.7	0.0375	10.9	0.0914	0.008		15	180.00
7-344	180	150	0-90	45	9.75	0.103	2.20	0.455	0.008		15	180.00
7-345	180	335	0-200	84	23.9	0.0418	6.29	0.159	0.008		15	180.00
7-348	120	100	0-60	98	6.71	0.149	1.46	0.683	0.008		10	180.00
7-347	120	225	0-135	90	15.1	0.0662	3.17	0.315	0.008		15	165.00
7-343	120	335	0-200	61	33.3	0.0300	6.06	0.165	0.008		15	180.00
Fluid Damped					ma/in	in/ma	v/in	in/v				
7-364	200	833	0-500	69	0.400	2.50	0.107	9.37	0.008		50	165.00
7-363	200	1670	0-1000	69	2.0	0.50	0.533	1.875	0.005		100	165.00
7-362	200	4150	0-2500	69	12.0	0.0833	3.23	0.31	0.005		100	165.00
7-361	55	8000	0-5000	57	46.1	0.0217	5.29	0.189	0.005		100	205.00

HIGH TEMPERATURE GALVANOMETERS (5)

Magnetically Damped					μa/in	in/μa	mv/in	in/mv				
7-350	350	20	0-12	36.1	2.67	0.375	1.03	0.970	0.020		15	225.00
7-352	350	100	0-60	42.1	12.1	0.0826	4.74	0.211	0.016		15	215.00
7-354	180	150	0-90	36.1	29.9	0.0344	6.45	0.155	0.012		25	205.00
7-355	120	225	0-135	121	14.2	0.0704	3.42	0.292	0.008		15	225.00
Fluid Damped					ma/in	in/ma	v/in	in/v				
7-381	1000	1000	0-600	28	2.5	0.40	2.56	0.390	0.008		100	205.00
7-382	55	5000	0-3000	65	32.2	0.0311	3.86	0.259	0.005		100	215.00

SPECIALIZED GALVANOMETERS

7-353	An integrating-type galvanometer whose response is inversely proportional to frequency from 8 to 800 cps. See Bulletin 1517.	215.00
7-370	A computing-type galvanometer whose response is either the product, sum, or difference between two signals. Flat response from 0-800 cps. See Bulletin 1605.	375.00

NOTES:

(1) For 64% critical damping.

(2) The System Voltage sensitivity relates the galvanometer trace deflection (inches) on the record to the open-circuit voltage of a transducer having a source resistance equal to (1) above. (Previous CEC galvanometer-characteristics charts have stated voltage sensitivity in terms of voltage applied to the coil. These values should not be compared to the present sensitivities, since the two are based on different circuitry conditions.)

(3) Deflection of trace in inches per "g" at 11.5-inch optical arm.

(*4) Add $15.00 for special balance.

(5) Specifications based on operation at 175°F ±25°F.

5-119P4
2061 6-59

FIG. 3:06

(2) Engage the scanning-system gear at the left (Fig. 1:03) by pushing it to the right along its shaft until it meshes with the high-speed gear. The gear is of light construction and should be moved by minimum pressure applied near its shaft.

(3) Pull the scan-lens-control lever up to a vertical position and maintain light finger pressure on it. Turn the scan-system gear until a gentle click is heard and the lever moves about one half inch farther. This indicates that a detent has engaged the scan polygon mirror and positioned it so that a galvanometer beam striking the vertical center of the scanning screen will also be centered on the collimating lens of the recording system. The galvanometer beams will now appear as vertical streaks on the viewing screen.

(4) Right and left adjustment of the reflected streak of light is accomplished by placing the socket end of the galvanometer-adjusting tool over the top post, and turning the galvanometer element clockwise or counterclockwise, while noting the streak position on the viewing screen. Vertical lines on the screen are spaced 0.1 inch apart; the distance between the outer lines is twelve inches.

CAUTION

Galvanometers contain stops to limit lateral adjustment to 90° left and right from center. However, because of the small size of the entire galvanometer assembly, these stops are of limited strength. When resistance is felt, therefore, do not apply more force. Certain older galvanometers of the 7-200 series do not have such stops, and particular care must be taken to limit rotation to one-quarter turn left or right from the straight forward position.

b. Vertical adjustment

Insert the cam end of the galvanometer wrench into the hole behind the galvanometer until it engages the control at the bottom. Turning the wrench clockwise tilts the galvanometer forward, counterclockwise tilts it back. Adjust as necessary until the vertical center of the light streak crosses the horizontal lines on the viewing screen and is spaced equidistant above and below the lines. The galvanometer will then produce the optimum image on the record.

NOTE: It may be necessary to check back and forth between the lateral and vertical adjustments, but the final height adjustment must be left undisturbed.

Return the control lever to the horizontal position when the adjustments are completed, and before using the scanning system for observing waveforms.

c. Galvanometer removal

(1) With the eccentric type adjusting tool, turn the adjusting slot of the channel being removed to its full-rear position, i.e., turn the tool full counterclockwise.

(2) The lifting tool should be employed whenever galvanometers are installed or removed from the block (Fig. 3:02).

(a) Place the lifting tool over a galvanometer so the prongs fit under the lens turret.

(b) Hold the galvanometer securely by squeezing the spring-loaded lever with the thumb.

(3) Remove the galvanometer by attaching the lifting tool and reversing installation procedure. Brace the hand against the oscillograph case to gain additional leverage against the pull of the magnet block, and pull straight outward.

7-004 DYNAMIC REFERENCE TRACE GALVANOMETER

SPECIFICATIONS

Flat frequency range	0-2000 cps
Resonant frequency	3400 cps
Sensitivity	28 ma/in
Terminal resistance	56 ohms
Safe current	100 ma
Fluid damping	68% of critical damping

MOUNTING INSTRUCTIONS

This dynamic reference trace galvanometer is for use with those CEC recording oscillographs which have been designed to accommodate it. These oscillographs have two small screw holes in the center of the side plate, or plates of the galvanometer magnet block.

Two tapped holes are located in the top portion of the bracket (see illustrations on opposite page); only one is used at any given time, however. This arrangement permits the attachment of the bracket to either side of the reference trace, the position chosen depending upon whether the operator wishes to mount the reference trace on either the right-hand or left-hand end of the block.

ASSEMBLY

Insert the base of the galvanometer into the channel on the bracket, the thin tabular portion of the bracket to the top. Slide the bracket slowly up the galvanometer body. Engage the springs at the base of the bracket in the runners in the body and continue to move the bracket up the body of the instrument until the top threaded hole in the bracket aligns with the hole in the body of the galvanometer. The screw may now be inserted from the opposite side of the body into the bracket and tightened, drawing the bracket snugly up against the body of the galvanometer.

CAUTION

Care should be exercised in manipulating the retaining springs which protrude from the bottom of the retaining bracket. Their purpose is to hold the base of the bracket firmly against the body of the reference trace to prevent vibration. If handled too roughly, they may be damaged or broken.

INSTALLATION

The reference trace and bracket are designed to be mounted in the triangular opening between the end plate and the first galvanometer slot of the galvanometer block assembly (see accompanying illustrations on opposite page). Place the turret so that the yellow dot is on top for 11.5" optical arm. The red dot is on top for 7" optical arm cameras. Yellow dot: 5-114, 5-116, and 5-119; Red dot: 5-117 and 5-118.

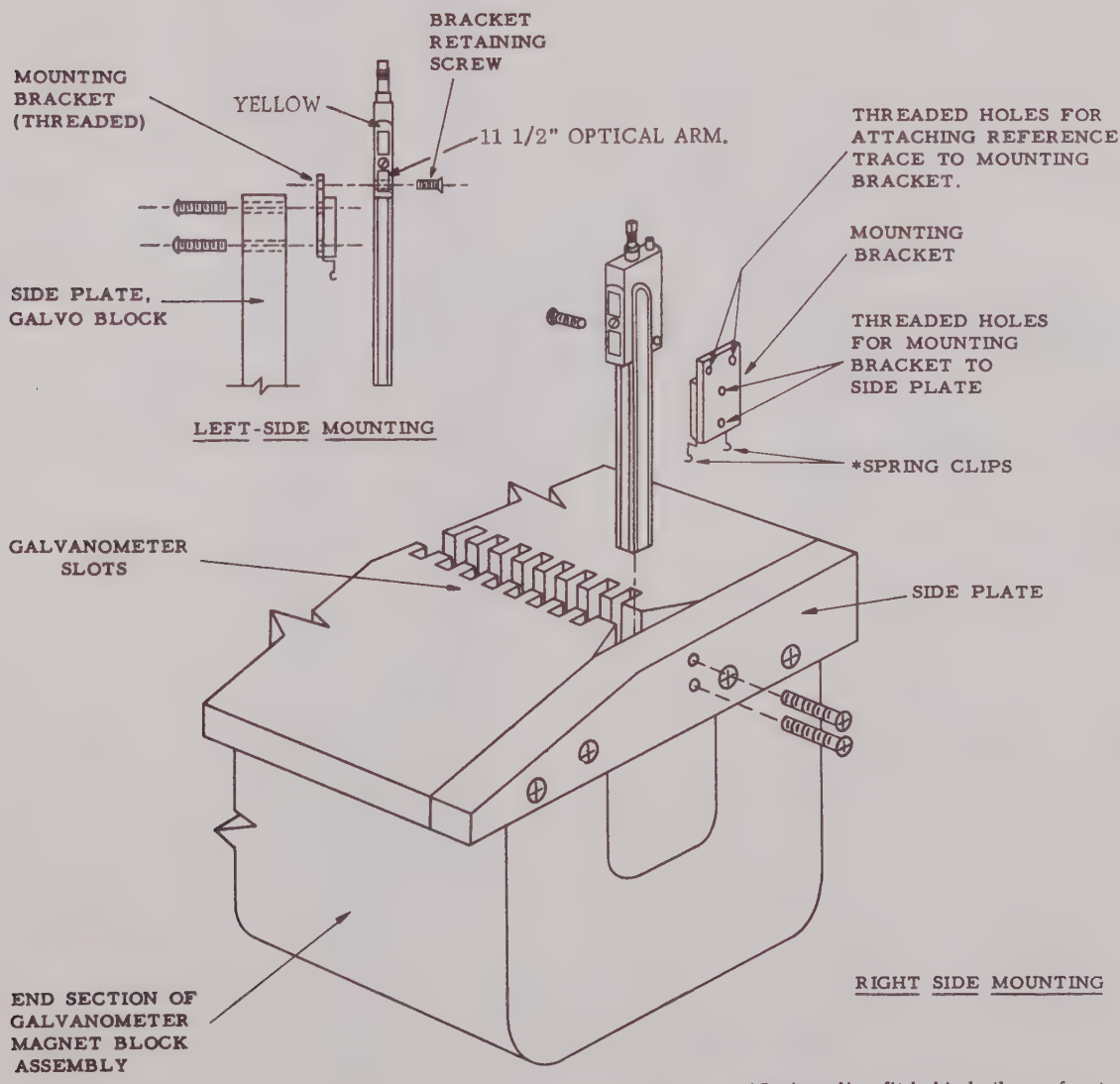
ADJUSTMENT

The dynamic reference trace spot should be positioned vertically on the collimating lens before the galvanometer is finally tightened into place against the side plate. Lateral adjustment of the spot is accomplished by adjusting the mirror for right and left deflection.

TYPE DIFFERENCES

Because of the differences in sensitivities, caution should be observed when replacing the earlier type dynamic-reference-trace galvanometers with the new Type 7-004 Galvanometer. The following table will serve as a reference for making the necessary corrections at the time the Type 7-004 Galvanometer is installed.

GALVANOMETER TYPE	BLOCK MOUNTING	FLAT FREQ. RANGE (CPS)	UNDAMPED D-C CURRENT SENSITIVITY		NOMINAL GALVANOMETER VOLTAGE SENSITIVITY	TYPE DAMPING
			ma/in	in/ma	v/in	
7-004	LEFT or RIGHT	0-2000	28.0	.036	1.57	FLUID
22261	RIGHT	0-2000	250.0	.004	6.0	FLUID
25170	LEFT	0-2000	250.0	.004	6.0	FLUID
17954	RIGHT	0-300	2.85	.35	.053	FLUID



*Spring clips fit behind ribs on front and rear of galvanometer body.

INSTALLATION OF DYNAMIC REFERENCE TRACE

The Theory of Recording Galvanometers

By M. A. LE GETTE

CONSOLIDATED ELECTRODYNAMICS

300 n. sierra madre villa
pasadena, california

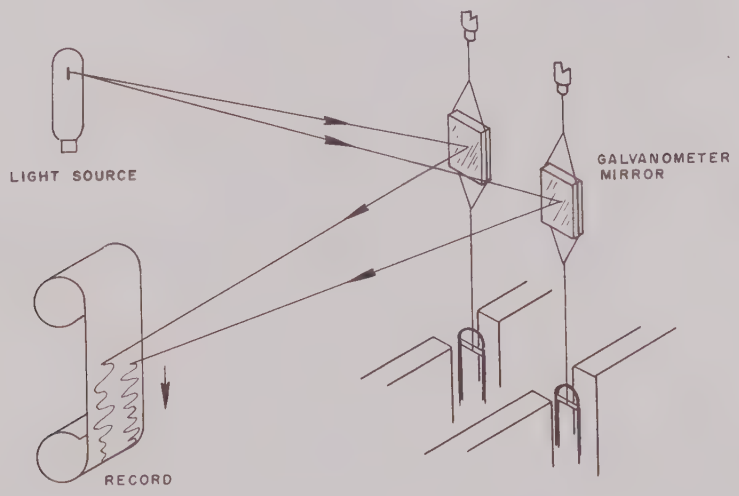
GALVANOMETERS

GENERAL

A galvanometer is an electromechanical transducer which accepts electrical energy and transforms it into mechanical rotational energy. Commonly, a mirror is rotated so that a light beam is moved laterally in proportion to the magnitude of current being introduced.

CEC oscillographs employ mirror-type galvanometers to deflect a light spot across a photosensitive chart (Fig. 1). These galvanometers are interchangeable, and because of their small size, as many as 50 may be installed in some CEC oscillographs.

Manufacturers of recording galvanometers are continually seeking improvements that will make possible galvanometers having smaller size, maximum sensitivity, greater frequency range, and good balance. Unfortunately, all of these characteristics cannot be incorporated to their fullest extent in any one type of galvanometer. Therefore, it is necessary to build a number of variations of the basic type to meet all requirements. CEC's galvanometers have natural frequencies ranging from 10cps to 8000cps, and sensitivities as high as 1.62 μa/inch.



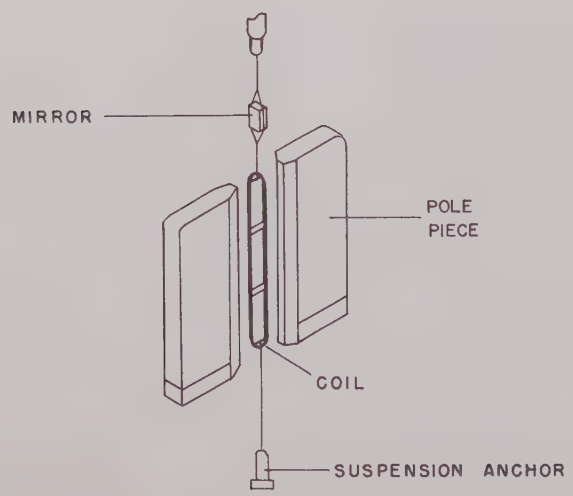


FIG. 1

This paper outlines the basic theory, the factors to be considered in selecting a galvanometer, and the input circuit parameters that must be considered for optimum performance.

THEORY

The rotational motion of a galvanometer mirror and suspension obeys the theory and formulas pertaining to damped, forced vibration. Within limits (namely, small oscillations about the equilibrium position), the lateral motion of the spot of light, reflected from the galvanometer mirror onto the record, will follow the basic vibration differential equation:

$$m\ddot{x} + c\dot{x} + kx = P_o \sin 2\pi ft \tag{1}$$

where m = mass moment of inertia of the coil-suspension system
c = damping constant
k = spring constant of the galvanometer suspension
P_o = peak amplitude of the driving force
f = frequency of the driving force
x = linear displacement of the spot of light on a plane surface

The undamped natural frequency or resonant frequency is derived from Equation (1) when $c = 0$ and $P_o = 0$.

$$m\ddot{x} + kx = 0 \tag{2}$$

A general solution of Equation (2) may be represented by the following:

$$x = X \sin(2\pi f_n t + \phi) \tag{3}$$

where X = amplitude of the oscillation
f_n = undamped natural frequency or resonant frequency
φ = phase angle

f_n can be determined by first differentiating Equation (3) as follows:

$$\dot{x} = X(2\pi f_n) \cos(2pf_n t + \phi)$$

$$\ddot{x} = -X(2\pi f_n)^2 \sin(2\pi f_n t + \phi) \tag{4}$$

then substituting Equations (3) and (4) in Equation (2), we have

$$-mX(2\pi f_n)^2 \sin(2\pi fnt + \phi) + kX\sin(2\pi f_n t + \phi) = 0$$

and factoring, we have

$$\left[-m(2\pi f_n)^2 + k\right]\left[\sin(2\pi f_n t + \varphi)\right] = 0$$

$$m(2\pi f_n)^2 = k$$

$$f_n = \frac{1}{2\pi}\sqrt{\frac{k}{m}} \qquad (5)$$

This term is the undamped natural frequency shown on CEC's galvanometer specification card.

When the instantaneous driving force ($P_o \sin 2\pi ft$) equals zero, Equation (1) is satisfied by the solution for damped free vibration. In free vibration, the oscillation is damped because of energy dissipated by the fluid, and the electromagnetic effect.

$$m\ddot{x} + c\dot{x} + kx = 0 \qquad (6)$$

Assume the solution

$$x = e^{rt}$$

where r is a constant to be determined. Substituting in Equation (6), we have

$$(r^2 + \frac{c}{m}r + \frac{k}{m})e^{rt} = 0$$

then

$$r^2 + \frac{c}{m}r + \frac{k}{m} = 0$$

and

$$r_{1,2} = -\frac{c}{2m} \pm \sqrt{\left(\frac{c}{2m}\right)^2 - \frac{k}{m}} \qquad (7)$$

The solution may then be written as

$$x = Ae^{r_1 t} + Be^{r_2 t}$$

where A and B are arbitrary constants. r may be either real, imaginary, or zero. The value of c that makes the radical in Equation (7) zero is defined as the critical damping value c_c.

$$(c_c/2m)^2 - k/m = 0$$

$$c_c/2m = \sqrt{k/m} = 2\pi f_n$$

$$c_c = 2m\sqrt{k/m} \qquad (8)$$

h is defined as the per-unit damping factor and equals c/c_c.

Therefore,

$$c/2m = (c/c_c)(c_c/2m) = h2\pi f_n$$

Substituting in Equation (7)

$$r_{1,2} = -h2\pi f_n \pm \sqrt{(h2\pi f_n)^2 - (2\pi f_n)^2}$$

$$r_{1,2} = (-h \pm \sqrt{h^2 - 1})\, 2\pi f_n \qquad (9)$$

From Equation (9) it is evident that there are three cases of interest, namely:

h less than 1
h greater than 1
h equal to 1

We shall next consider the solution for each of these cases separately.

The solution of Equation (6) is called the transient solution or complimentary function, and is represented by the following equation in the underdamped case (h is less than 1).

$$x = e^{-h2\pi f_n t}(Ae^{i\sqrt{1-h^2}2\pi f_n t} + Be^{-i\sqrt{1-h^2}\,2\pi f_n t})$$

By indentity, x can be written as

$$x = A_1 e^{-h2\pi f_n t} \sin(\sqrt{1-h^2}2\pi f_n t + \phi) \qquad (10)$$

where A_1 = displacement of the envelope when t = 0
h = c/c_c = ratio of actual damping to critical damping
f_n = undamped natural frequency
t = time
ϕ = phase angle

$\sqrt{1-h^2}\ f_n = f_d$ = frequency of damped oscillation

Equation (10) is shown graphically in the figure below.

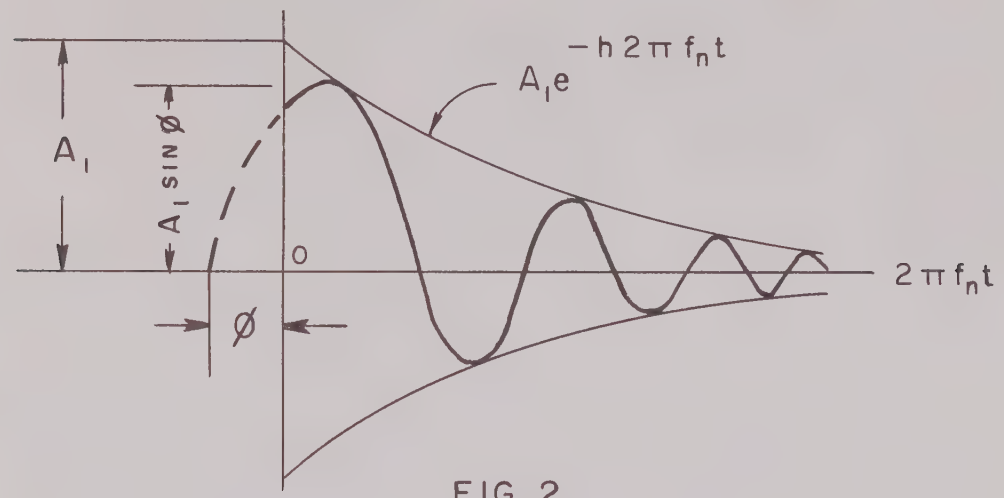


FIG. 2

The second solution of Equation (6) for the overdamped case (h is greater than 1) can be represented by the following equation:

$$x = Ae^{(-h+\sqrt{h^2-1})2\pi f_n t} + Be^{(-h-\sqrt{h^2-1})2\pi f_n t} \qquad (11)$$

Equation (11) is shown graphically in the figure below.

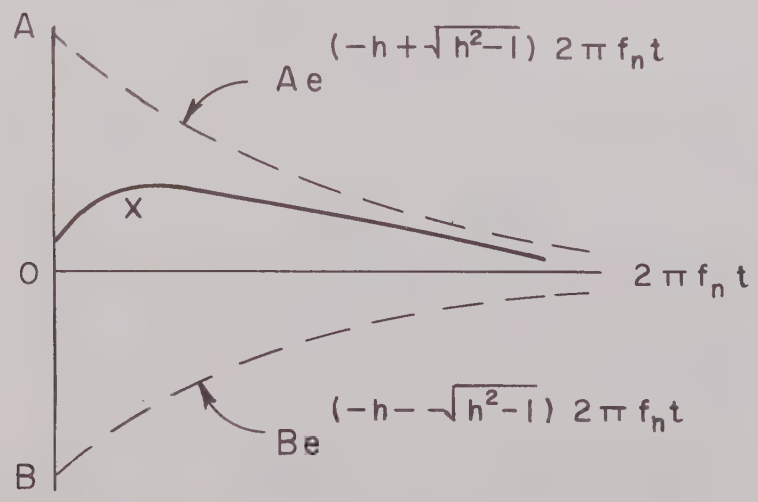


FIG. 3

This solution is nonvibratory. The motion is aperiodic and the body tends to creep back to the equilibrium position.

The third solution of Equation (6) for the critically damped case (h equals 1), which is the transition between the oscillatory and nonoscillatory conditions, can be represented by the following equation:

$$x = (A + Bt)\, e^{-2\pi f_n t} \qquad (12)$$

Equation (12) is shown graphically in the figure below when A = 0.

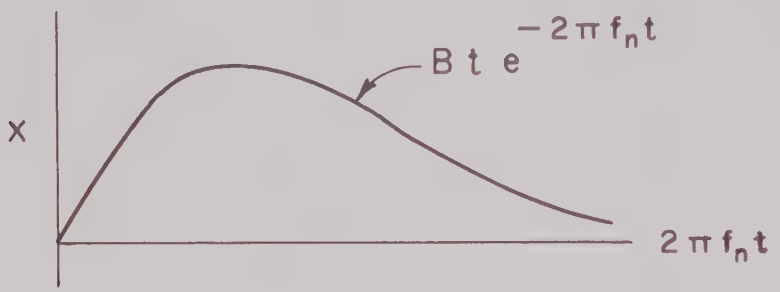


FIG. 4

This solution is similar to that shown in Fig. 3. A system with critical damping has the smallest damping possible for aperiodic motion, and hence returns to rest in the shortest period of time without oscillation.

The general solution of Equation (1).

$$m\ddot{x} + c\dot{x} + kx = P_o \sin 2\pi ft \qquad (1)$$

Inertia Force + Damping Force + Spring Force = Driving Force

The general solution to this equation is made up of two parts--the sum of the transient solution or complimentary function, and the steady-state solution or particular solution. The damped motion shown in Fig. 2 and represented by the transient solution (Equation 10) soon disappears, after which only the steady-state oscillations remain. Vibratory motion can be maintained at constant amplitude by an external source of energy. In a galvanometer, this energy is supplied by the applied signal.

Equation (10) is the transient solution for h less than 1.

The following equation is a particular solution of the differential Equation (1) and represents the steady-state oscillation:

$$x = S \sin (2\pi ft - \theta) \qquad (13)$$

where S is the amplitude and θ the phase angle by which the motion lags the driving force. f is the frequency of oscillation.

Substituting Equation (13) in Equation (1):

$$\dot{x} = 2\pi fS \cos(2\pi ft - \theta) = 2\pi fS \sin(2\pi ft - \theta + \pi/2)$$

$$\ddot{x} = -4\pi^2 f^2 S \sin(2\pi ft - \theta)$$

then

$$+ m4\pi^2 f^2 S \sin(2\pi ft - \theta) - c2\pi fS \sin(2\pi ft - \theta + \pi/2) - kS \sin(2\pi ft - \theta)$$

$$+ P_o \sin(2\pi ft) = 0 \qquad (14)$$

The terms of Equation (14) can be plotted vectorially in the following manner:

P_o is the amplitude of the driving force at an angle $2\pi ft$.

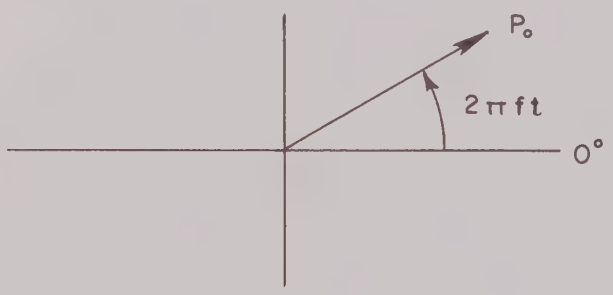


FIG. 5

S is the amplitude of oscillation and lags P_o by an angle θ.

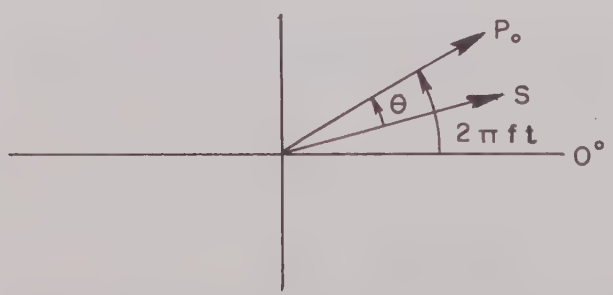


FIG. 6

kS is the amplitude of the spring force and is opposite in direction to the deflection amplitude S.

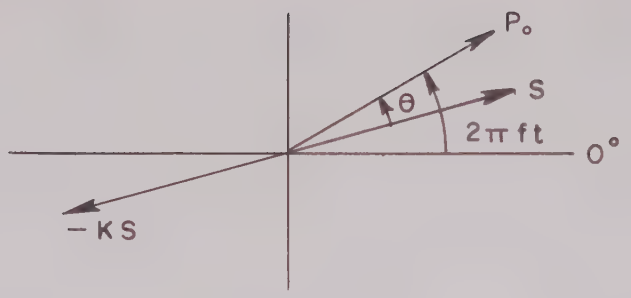


FIG.7

The amplitude of the damping force ($-c2\pi fS$) lags the deflection amplitude by 90°, and is opposite in direction to the velocity.

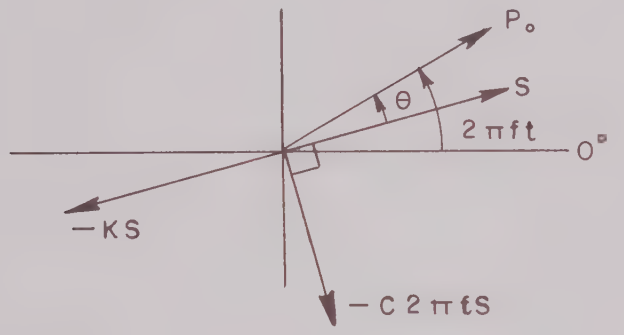


FIG. 8

The amplitude of the inertia force ($m4\pi^2 f^2 S$) is in phase with the deflection amplitude and opposite in direction to the acceleration.

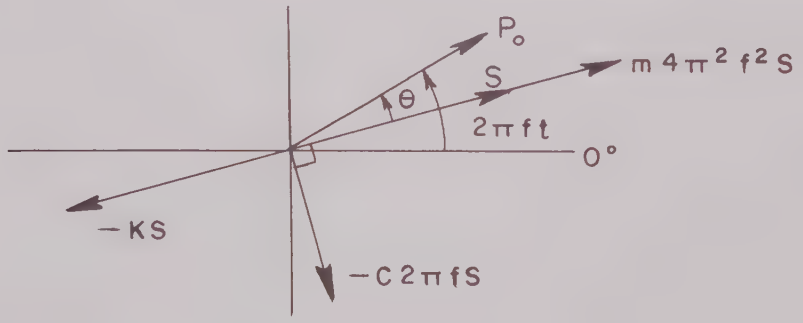


FIG. 9

We can rearrange the vectors in the following manner:

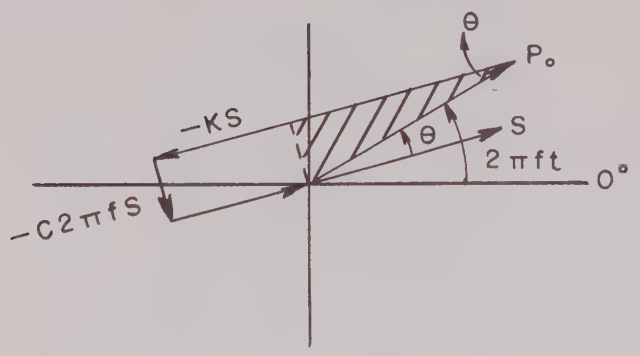


FIG. 10

Redrawing the shaded portion of Fig. 10, we have

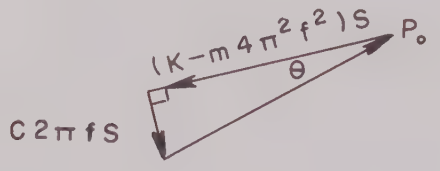


FIG. 11

From Fig. 11, the following equations can be written:

$$P_o^2 = (c2\pi fS)^2 + [(k-m4\pi^2f^2)S]^2$$

Solving for S

$$S = \frac{P_o}{\sqrt{(c2\pi f)^2 + (k-m4\pi^2f^2)^2}} \qquad (15)$$

$$\tan\theta = \frac{c2\pi f}{k - m4\pi^2f^2} \qquad (16)$$

Dividing both numerator and denominator in Equations (15) and (16) by the spring constant k:

$$S = \frac{P_o/k}{\sqrt{(1 - 4\pi^2mf^2/k)^2 + (2\pi cf/k)^2}} \qquad (17)$$

$$\tan\theta = \frac{2\pi cf/k}{1 - 4\pi^2mf^2/k} \qquad (18)$$

Let S_o equal the value of S in Equation (17) when f = 0. S_o will then be equal to P_o/k.

Combining Equations (5) and (8), we have

$$c_c = 4\pi m f_n \tag{19}$$

Substituting in Equations (15) and (16)

$$S/S_o = \frac{1}{\sqrt{\left[1 - (f/f_n)^2\right]^2 + (2hf/f_n)^2}} \tag{20}$$

$$\tan \theta = \frac{2hf/fn}{1 - (f/f_n)^2} \tag{21}$$

$$\text{or } \theta = \text{Arc tan } \frac{2hf/f_n}{1 - (f/f_n)^2} \tag{22}$$

S/S_o is called either the relative deflection or per-unit sensitivity. The sensitivity of a galvanometer is the deflection per-unit current. Therefore, the ratio of actual sensitivity to nominal sensitivity quoted in CEC's specifications equals S/S_o. The curves shown in Figs. 12 and 13 are plots of Equations (20) and (22) for various values of the damping factor h.

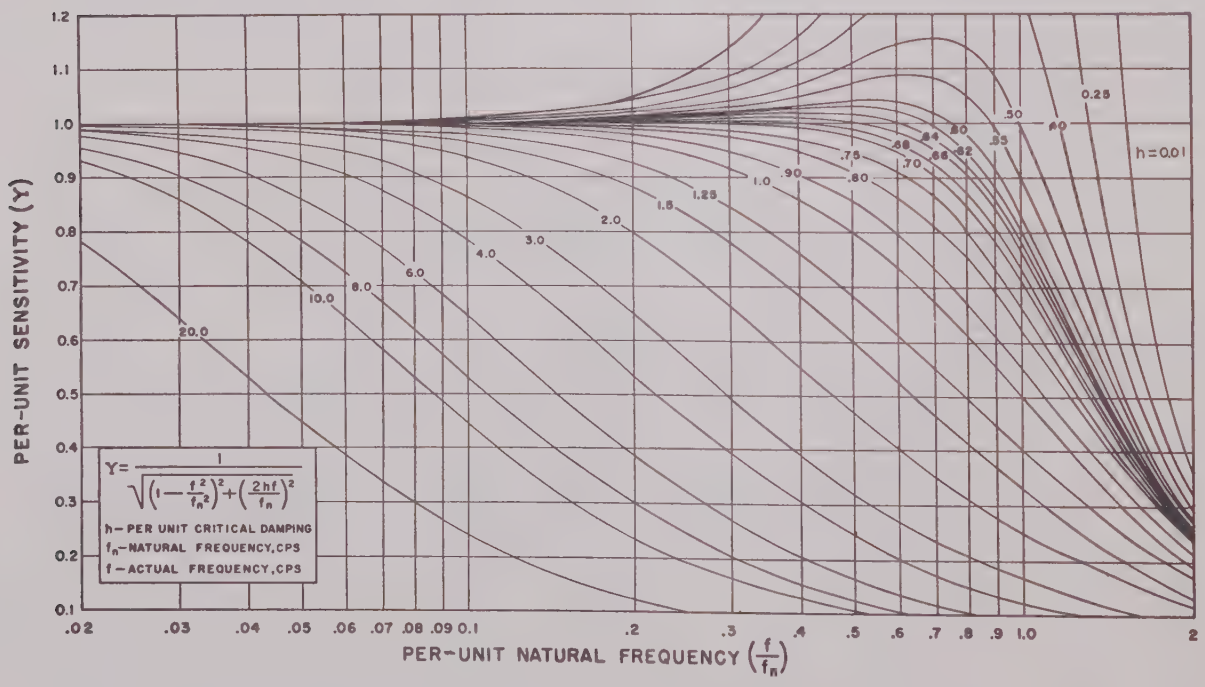


FIG. 12

Fig. 12 is the family of response curves with the per-unit damping h as parameter.

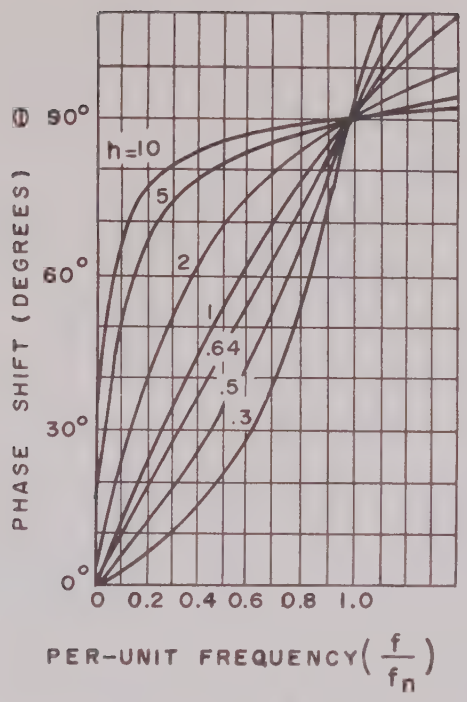


FIG. 13

CEC galvanometers nominally employ .64 per-unit damping. This value yields a flat frequency response (within ±2%) out to at least .6 f_n, and approximately a linear variation of phase angle with frequency. The latter is very desirable, so that the time relationship between the fundamental and its harmonics is not destroyed.

Adding Equation (10) and Equation (13), and substituting Equation (15) in Equation (13), we can write the general solution to Equation (1):

$$x = A_1 e^{-h2\pi f_n t} \sin(\sqrt{1 - h^2}\, 2\pi f_n t + \phi) + \frac{P_o \sin(2\pi f t - \theta)}{\sqrt{(k - 4\pi^2 f^2 m)^2 + (2\pi f c)^2}} \qquad (23)$$

This equation represents the sum of the transient and particular solution, which yields the general solution of Equation (1) for h less than 1.

Thus far, reference has been made to the natural frequency f_n and the frequency of damped oscillation f_d. A third frequency of interest is called the frequency of maximum forced amplitude f_m. This frequency can be found by minimizing the denominator of Equation (20).

$$\text{Denominator} = D = \left[1 - (f/f_n)^2\right]^2 + (2hf/f_n)^2$$

Differentiating D with respect to $(f/f_n)^2$, and setting the results equal to zero:

$$dD/d(f/f_n)^2 = -2\left[1 - (f/f_n)^2\right] + (2h)^2 = 0$$

$$f/f_n = \sqrt{1 - 2h^2} \text{ or}$$

$$f = f_m = \sqrt{1 - 2h^2}\, f_n$$

The family of curves shown in Fig. 14 clearly illustrates the effect of various damping factors on f_m.

$$f_n = \frac{1}{2\pi}\sqrt{k/m} \tag{24}$$

$$f_d = \sqrt{1 - h^2}\, f_n \tag{25}$$

$$f_m = \sqrt{1 - 2h^2}\, f_n \tag{26}$$

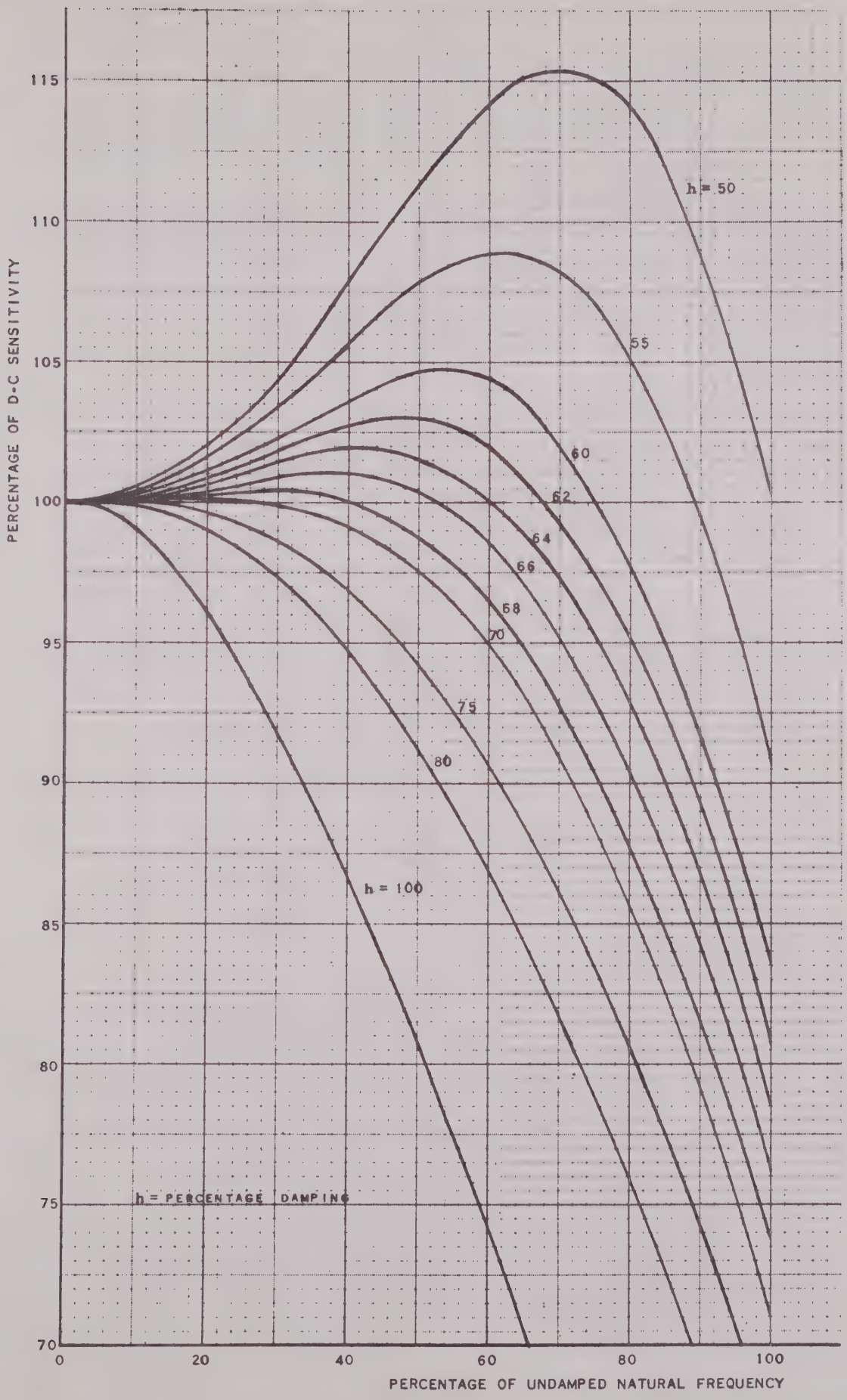


FIG. 14

1582 7-57

SELECTING THE PROPER GALVANOMETER

Selection of the proper instrument to measure a physical quantity involves the consideration of a number of parameters. An understanding of the parameters used in specifying a galvanometer, or any other instrument, is essential in obtaining the desired results and performance. The value that must be placed on any one parameter will depend upon the particular application in which the galvanometer is to be used. The following discussion covers the major parameters to be considered in selecting the proper galvanometer.

Sensitivity:

This term is defined as the amount of deflection per unit current (Fig. 15). CEC specifies their galvanometer sensitivity at ± 2 inches from its straight ahead position. Since the amount of deflection for a given current is directly proportional to the distance from the mirror to the screen (optical arm), this distance must be specified when quoting a sensitivity. CEC oscillographs have either a 7.5-inch or 11.5-inch optical arm.

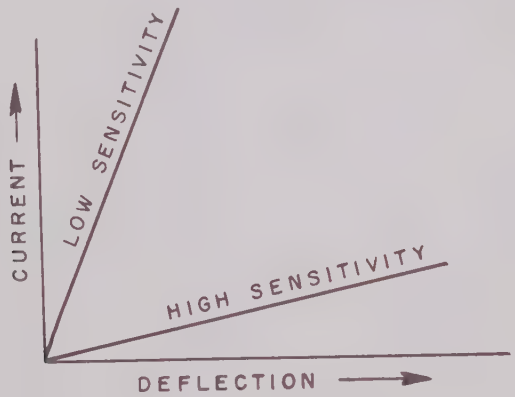


FIG. 15

Linearity:

A galvanometer whose spot deflection is directly proportional to the driving current is said to be linear (Fig. 16). With the galvanometers correctly installed in the magnet block, the majority of CEC galvanometers will display a best-line linearity of less than 1% of full-scale deflection (± 2 inches at an 11.5-inch optical arm). The major portion of this non-linearity results from the fact that spot deflection is a function of the angular rotation of the suspension, and light beams are recorded on a flat surface rather than a curved surface, thereby introducing a tangential error. The galvanometer suspension rotating in a parallel magnetic field tends to correct this tangential error to some extent. This correction is called a cosine error, which is opposite in direction to the tangential error.

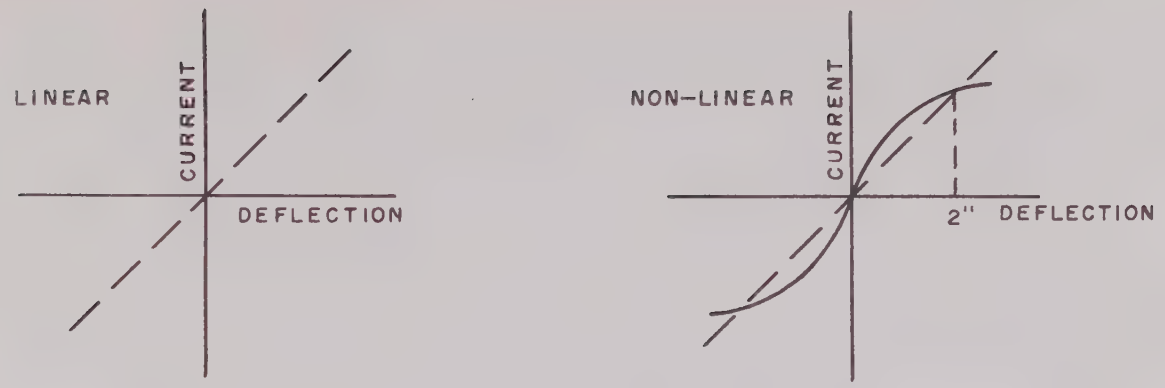


FIG. 16

Non-symmetry is when the deflection either side of the straight ahead position is not the same. This also contributes to the non-linearity of the galvanometer. Precision instruments are required to measure accurately the percent of non-linearity. This cannot be done using the viewing screen of an oscillograph.

Frequency Response:

Galvanometers are primarily used to record alternating current, and it is necessary that the spot deflection be proportional to the instantaneous current over the frequency range of interest. CEC galvanometers employ a damping value which is 64% of critical (Fig. 17).

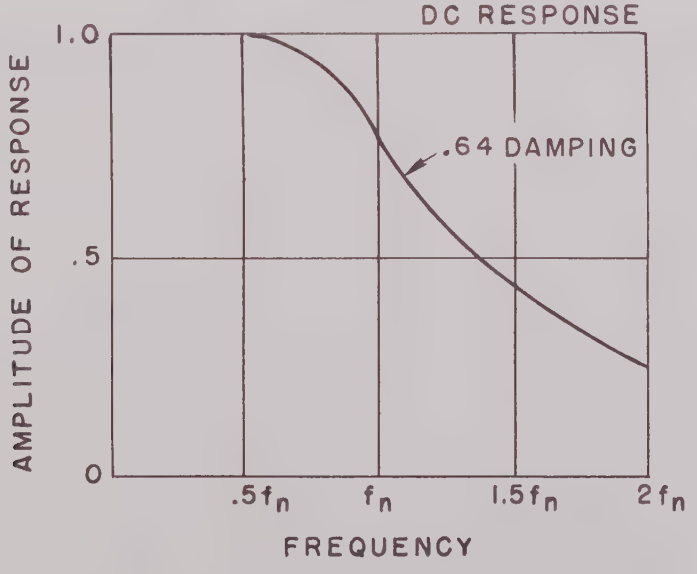


FIG. 17

With this damping value, a particular galvanometer will have a frequency response which is flat to within ±2% out to at least .6 of its natural frequency. Per-unit response to frequencies beyond $2f_n$ will be small and essentially filtered out. Hence, galvanometers with low natural frequencies make excellent low-pass filters to eliminate undesirable higher frequencies.

Figure of Performance:

To assist in making comparisons between galvanometers in which neither sensitivity nor undamped natural frequency is a common factor, a yardstick called the Figure of Performance has been developed. The Figure of Performance of any galvanometer may be calculated from the following equation:

$$F.P. = KSf_n^2 \qquad (27)$$

where

K = constant = 10^{-4}

S = Sensitivity of galvanometer (mm/ua at a one-meter optical arm)

f_n = Undamped natural frequency (cps)

CEC's high-performance galvanometers have Figure of Performance values as high as 42.

Static Balance:

This term delineates the ability of the manufacturer to maintain true mass symmetry of the galvanometer coil, mirror, and suspension about its axis of rotation. Deviations from perfect mass symmetry can cause a galvanometer to respond to linear vibration or acceleration forces. The small couples which exist under such conditions can rotate the mirror and lead to inaccuracies on the record. The amount of unbalance translated into spot deflection, which will be evidenced at a stated optical arm when the galvanometer is subjected to a lateral acceleration of 1 g, is given as "Balance" in CEC's specifications.

Damping Resistance:

For optimum galvanometer operation, the driving-circuit resistance presented to the galvanometer should be equal to the resistance specified by the manufacturer for 64% critical damping.

When the driving-source resistance does not equal the specified damping resistance, an appropriate network must be provided to obtain the optimum 64% of critical damping.

INPUT CIRCUIT PARAMETERS

As pointed out previously, the galvanometer must be properly damped for optimum performance. The required external damping resistance ss stated in CEC's specifications will give optimum (64% ± 5% of critical) damping. The resistance value stated is R_D in the following diagrams.

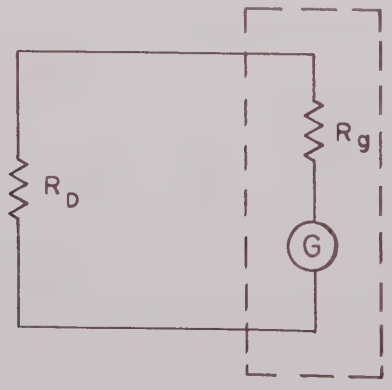
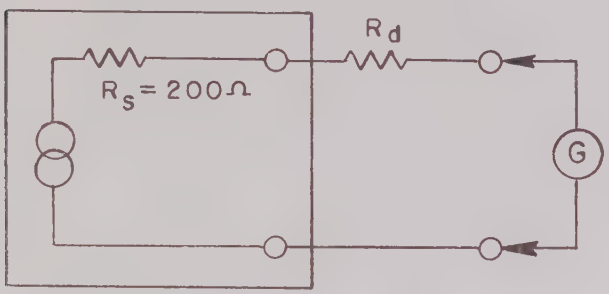


FIG. 18

In any application the source impedance must be considered in obtaining proper damping. Fig. 19 describes the method for calculating the proper value of series resistance when the source impedance is low, and Fig. 20 describes the method for calculating the proper value of shunt resistance when the source impedance is high.



7-315 GALVANOMETER

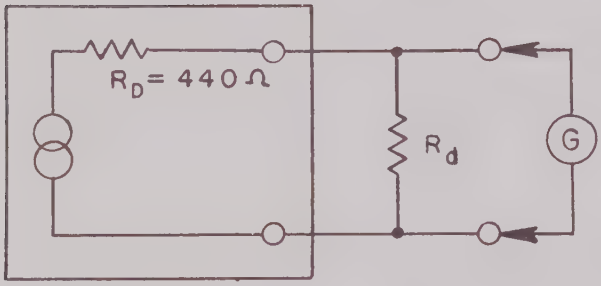
$R_D = 350\Omega$

$R_S < R_D$

$R_D = R_d + R_S$

$R_d = R_D - R_S = 350 - 200 = 150\Omega$

FIG. 19



7-338 GALVANOMETER

$R_D = 120\Omega$

$R_S > R_D$

$$R_d = \frac{R_S R_D}{R_S - R_D}$$

$$= \frac{(440)(120)}{(440-120)} = 165\Omega$$

FIG. 20

When matching a galvanometer to an amplifier, it is necessary to consider galvanometer damping, the galvanometer current required for the desired spot deflection, and the proper loading for the amplifier (Fig. 21).

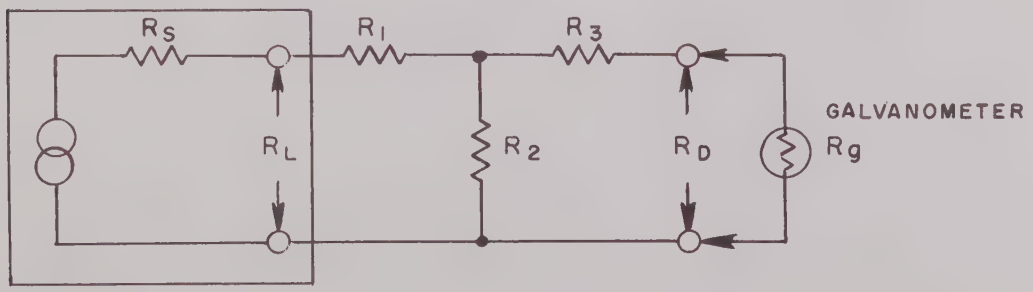


FIG. 21

The following procedure will define a resistor network which will properly match a galvanometer to an amplifier.

R_L = Optimum load resistance for amplifier (ohms)

R_S = Output resistance of amplifier (ohms)

R_D = Required damping resistance for galvanometer (ohms)

*S = Galvanometer sensitivity (ma/inch)

R_g = Galvanometer terminal resistance (ohms)

*D = Trace deflection desired (inches)

I_o = Amplifier current, full scale (ma)

K = Constant

*S and D must be calculated for the same optical arm.

1. $R_1 = R_L - (1-K)R_2$ (28)

2. $R_2 = K(R_g + R_D)\left[\frac{1}{1 - K^2\left[(R_g+R_D)/(R_L+R_S)\right]}\right]$ (29)

3. $R_3 = \frac{(1-K)}{K}R_2 - R_g$ (30)

4. $K = SD/I_o$ (31)

Example:

To match CEC's 7-320 Galvanometer to a CEC 1-127 Carrier Amplifier:

I_o = 48.2 ma.

R_s = 55 ohms

R_L = 52 ohms

R_D = 200 ohms

R_g = 24 ohms

D = 2 inches

S = 2.32 ma/in

$$K = \frac{SD}{I_o} = \frac{2.32 \times 2}{48.2} = .096$$

$$R_2 = .096 \quad (24 + 200)\left[\frac{1}{1 - (.096)^2 \quad \frac{(24 + 200)}{(52 + 55)}}\right] = \underline{22\ \Omega}$$

$$R_3 = \frac{(1 - .096)}{.096}\ 22 - 24 = 207 - 24 = \underline{183\ \Omega}$$

$$R_1 = 52 - (1 - .096)\ 22 = 52 - 20 = \underline{32\ \Omega}$$

At times it may be desirable to use special values of damping to satisfy a system requirement. Using the values for 0.64 damping as a base, special values may be calculated.

(a) Air damping, electromagnetic damping, and a small amount of fluid damping make up the damping effect in magnetically damped galvanometers. In CEC's fluid-damped galvanometers, the fluid provides approximately 95% of the total damping.

(b) The induced EMF, which produces the electromagnetic damping, results from the galvanometer coil cutting lines of flux. It can be represented by the following equation:

$$E = - \frac{\partial \varphi}{\partial t} \tag{32}$$

where φ is the flux across the pole pieces.

This can be rewritten as

$$E = - \frac{\partial \varphi}{\partial \theta} \frac{d\theta}{dt} \tag{33}$$

where θ is the angle between the plane of the galvanometer coil and the magnetic field. Since ϕ is a function of θ only, and θ is small:

$$\phi = (\text{constant}) \sin \theta$$

$$\sin \theta = \theta \quad \text{for } \theta \text{ small}$$

$$\text{then} \quad \phi = (\text{constant})\ \theta$$

This gives rise to a current.

$$i = -\frac{1}{R_B}\frac{d\varphi}{d\theta}\frac{d\theta}{dt} \qquad (34)$$

where $R_B = R_D + R_g$

R_D = external damping resistance

R_g = coil resistance of the galvanometer

The restoring torque

$$T_r = i\frac{d\varphi}{d\theta} \qquad (35)$$

Substituting Equation (34) in Equation (35)

$$T_r = -\frac{1}{R_B}\left[\frac{d\varphi}{d\theta}\right]^2\frac{d\theta}{dt} = -(\text{constant})\frac{d\theta}{dt} \qquad (36)$$

This constant can be defined as c_m, the electromagnetic component of the damping coefficient c. c_m is proportional to h_m (per-unit electromagnetic damping). Therefore, h_m is inversely proportional to R_B.

i.e. $$\frac{h_{m1}}{h_{m2}} = \frac{R_{D2} + R_g}{R_{D1} + R_g} \qquad (37)$$

(c) The total per-unit damping equals the sum of the electromagnetic per-unit damping and the viscous per-unit damping.

Example:

CEC's 7-315 Galvanometer

$h_m = .552$ $h_v = .088$ $R_D = 350\Omega$ $R_g = 33\ \Omega$

A total damping of .5 is desired.

The required damping resistance to give .5 per-unit damping can be calculated in the following manner:

$$h_t = h_m + h_v \text{ or } .5 = h_m + .088$$

$$h_m = .412$$

From Equation (37):
$$\frac{.412}{.552} = \frac{350 + 33}{R_{D1} + 33}$$

$$R_{D1} = 480\ \Omega$$

Special damping values may be advantageous for several reasons:

(a) To increase the sensitivity of the galvanometer to higher frequencies--reduced damping gives the frequency response curve a rising characteristic about the undamped natural frequency.

(b) To give a spot deflection, which is the integral of the signal current. CEC's 7-353 integrating galvanometer uses a damping value which is 18 times critical.

(c) To filter out high-frequency "noise". The galvanometer acts as a filter to frequencies above $2f_n$. By using higher damping, it is possible to attenuate frequencies much lower than this value. If a capacitor is shunted across the galvanometer, the sharpness of the cutoff will be improved.

The step-function response of a galvanometer, or rise time, is affected by the amount of damping (Fig. 22). A damping value of 0.64 will give approximately a 7% overshoot on the leading edge of a square wave. This value provides the optimum in rapid rise-time with minimized overshoot.

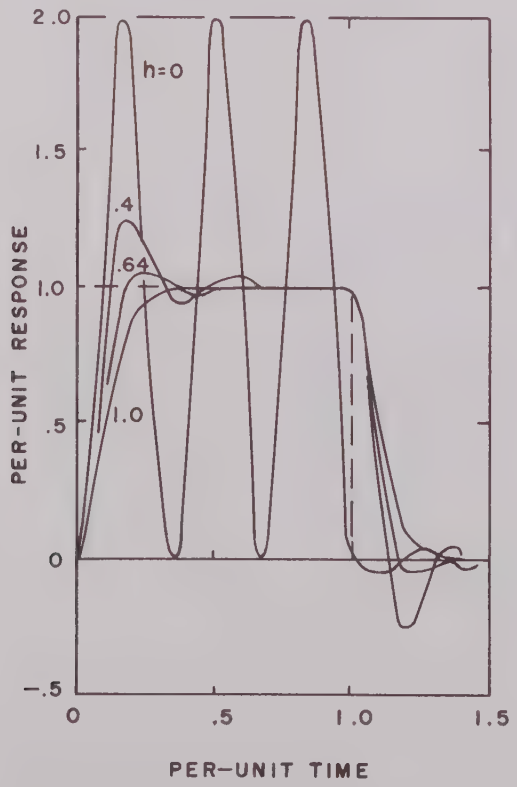


FIG. 22

The per-unit damping of a galvanometer can be determined from the percent overshoot on the leading edge of a square wave. Table 1 shows the various damping values as a function of the percent overshoot.

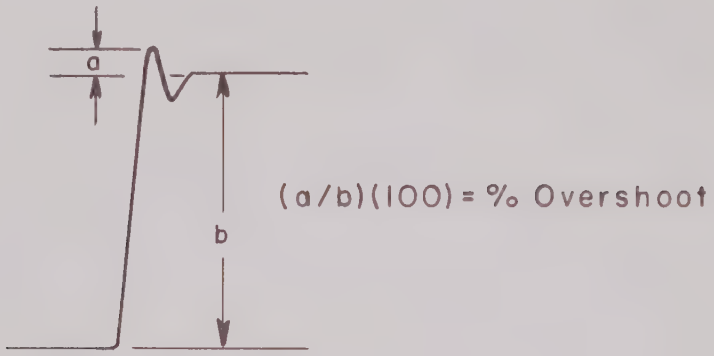


FIG. 23

A second method for determining the damping is from the rate of decay of oscillation. This rate is expressed by a term called the logarithmic decrement, which is defined as the natural logarithm of the ratio of any two successive amplitudes.

Consider a damped oscillation expressed by Equation (10) in the theory.

$$x = A_1 e^{-h2\pi f_n t} \sin(\sqrt{1-h^2} 2\pi f_n t + \phi) \qquad (10)$$

It may be represented graphically as

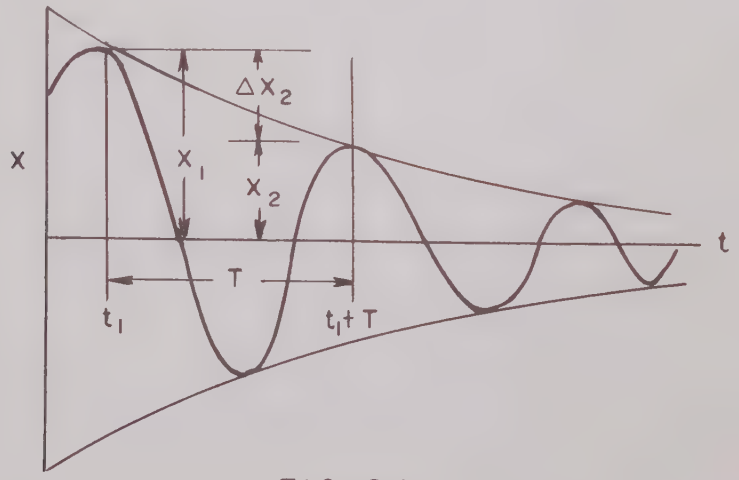


FIG. 24

Log decrement $$\partial = \ln (x_1/x_2) = \ln \left[e^{-h2\pi(f_n)(t_1)} \Big/ e^{-h2\pi f_n(t_1 + T)} \right]$$

$$= \ln e^{h2\pi f_n T} = h2\pi f_n T$$

The period of damped oscillation $= T = 1/f_d = 1/\sqrt{1-h^2}\ f_n$

Therefore

$$\partial = 2\pi h/\sqrt{1-h^2} = \ln\ (x_1/x_2) \qquad (38)$$

By measuring successive amplitudes, x_1 and x_2, as shown in Fig. 24, the damping h can be determined from Equation (38).

TABLE 1

% Overshoot	h	% Overshoot	h	% Overshoot	h
0.1	.911	5.0	.690	10.8	.577
0.2	.893	5.2	.685	11.0	.575
0.3	.888	5.4	.681	11.5	.567
0.4	.879	5.6	.676	12.0	.560
0.5	.861	5.8	.670	12.5	.551
0.6	.853	6.0	.666	13.0	.544
0.7	.845	6.2	.662	13.5	.537
0.8	.838	6.4	.658	14.0	.530
0.9	.831	6.6	.654	14.5	.524
1.0	.825	6.8	.650	15.0	.518
1.2	.815	7.0	.646	15.5	.511
1.4	.805	7.2	.642	16.0	.504
1.6	.796	7.4	.638	16.5	.497
1.8	.788	7.6	.634	17.0	.491
2.0	.780	7.8	.630	17.5	.485
2.2	.772	8.0	.626	18.0	.479
2.4	.765	8.2	.622	18.5	.473
2.6	.759	8.4	.619	19.0	.467
2.8	.752	8.6	.615	19.5	.461
3.0	.745	8.8	.612	20.0	.455
3.2	.739	9.0	.607	20.5	.499
3.4	.733	9.2	.605	21.0	.444
3.6	.727	9.4	.601	21.5	.439
3.8	.722	9.6	.597	22.0	.434
4.0	.716	9.8	.593	22.5	.429
4.2	.710	10.0	.591	23.0	.429
4.4	.705	10.2	.587	24.0	.414
4.6	.700	10.4	.584	25.0	.404
4.8	.694	10.6	.581		

The galvanometer specifications referred to in this paper are either theoretical or nominal values. Specifications of an individual galvanometer may vary slightly from the nominal values quoted in CEC's literature. Due to these production tolerances, it is important that individual circuits be calibrated to obtain accurate data reduction.

SPECIFICATIONS OF CEC HIGH-PERFORMANCE GALVANOMETERS

Type	External Damping Resistance Required Ohm (1)	Undamped Natural Frequency cps	Flat (±5%) Frequency Range cps	Nominal Coil Resistance Ohms	Sensitivity At 11.5 Inch Optical Arm				Static Balance (3)	Maximum Safe Current m.a.
					Undamped d-c Sensitivity		System Voltage Sensitivity (2)		Standard	
Magnetically Damped Galvanometers					μa/in	in/μa	mv/in	in/mv		
7-349	350	10	0-6	130	1.62	0.617	0.778	1.286	0.026	15
7-351	350	20	0-12	31	2.67	0.375	1.02	0.982	0.016	15
7-341	350	100	0-60	47	6.12	0.163	2.43	0.411	0.012	10
7-342	350	225	0-135	83	10.7	0.0935	4.67	0.214	0.008	15
7-346	350	320	0-190	60	26.7	0.0375	10.9	0.0914	0.008	15
7-344	180	150	0-90	45	9.75	0.103	2.20	0.455	0.008	15
7-345	180	335	0-200	79	24.3	0.0411	6.29	0.159	0.008	15
7-348	120	100	0-60	95	6.8	0.147	1.46	0.683	0.008	10
7-347	120	225	0-135	90	15.1	0.0662	3.17	0.315	0.008	15
7-343	120	335	0-200	61	33.3	0.0300	6.06	0.165	0.008	15
Fluid-Damped Galvanometers					ma/in	in/ma	v/in	in/v		
7-364	200	833	0-500	72	0.400	2.50	0.107	9.37	0.008	50
7-363	200	1670	0-1000	66	2.0	0.50	0.533	1.875	0.005	100
7-362	200	4150	0-2500	69	12.0	0.0833	3.23	0.31	0.006	100
7-361	55	8000	0-5000	57	46.1	0.0217	5.29	0.189	0.005	100

SPECIFICATIONS OF CEC STANDARD GALVANOMETERS

Type	External Damping Resistance Required Ohm (1)	Undamped Natural Frequency cps	Flat (±5%) Frequency Range cps	Nominal Coil Resistance Ohms	Sensitivity At 11.5 Inch Optical Arm				Static Balance (3)		Maximum Safe Current m.a.
					Undamped d-c Sensitivity		System Voltage Sensitivity (2)		Standard	Special	
Magnetically Damped Galvanometers					μa/in	in/μa	mv/in	in/mv			
7-325	350	18.5	0-11	18.5	7.9	0.127	2.92	0.343	0.050	0.025	15
7-339	350	50	0-30	30	4.61	0.217	1.75	0.572	0.032	0.016	15
7-315	350	100	0-60	33	12.2	0.0820	4.67	0.214	0.016	0.008	15
7-312	350	100	0-60	40	29.9	0.0334	11.7	0.0858	0.016	0.008	25
7-318	180	150	0-90	26	30.6	0.0327	6.29	0.159	0.016	0.008	25
7-338	120	210	0-125	24	58.3	0.0172	8.40	0.119	0.016	0.008	50
7-324	83	300	0-180	40	270	0.00370	33.3	0.030	0.016	0.008	50
7-319	25	585	0-350	25	435	0.00230	21.7	0.046	0.016	0.008	50
Fluid-Damped Galvanometers					ma/in	in/ma	v/in	in/v			
7-323	1000	1000	0-600	24	2.50	0.400	2.56	0.390	0.010	(4)	100
7-320	200	1000	0-600	24	2.32	0.431	0.521	1.92	0.010	4	100
7-316	200	2000	0-1200	24	9.17	0.109	2.05	0.487	0.005	(4)	100
7-317	28	3700	0-2200	24	41.4	0.0242	2.16	0.464	0.005	(4)	100
7-326	55	5000	0-3000	52	32.2	0.0311	3.44	0.291	0.005	(4)	100
7-353	An integrating-type galvanometer whose response is inversely proportional to frequency from 8 to 800 cps. See Bulletin 1517C.										

NOTES:

(1) For 64% critical damping.

(2) The System Voltage sensitivity relates the galvanometer trace deflection (inches) on the record to the open-circuit voltage of a transducer having a source resistance equal to (1) above. (Previous CEC galvanometer characteristics charts have stated voltage sensitivity in terms of voltage applied to the coil. These values should not be compared to the present sensitivities, since the two are based on different circuitry conditions.)

(3) Deflection of trace in inches per "g" at 11.5-inch optical arm.

(4) Not furnished. Standard balance normally satisfactory for all test requirements.

PART IV

SELECTION OF RECORDING MATERIALS AND ILLUMINATOR VOLTAGE SETTINGS

A. GENERAL

In a Consolidated recording oscillograph, light from the galvanometer illuminator is reflected by the galvanometer mirror, through a pair of lenses, to the photographic paper. The lenses focus the image of the illuminator filament and collimate it into a spot of light on the paper. The density of a recorded galvanometer trace is proportional to the intensity of the light spot, and the intensity is, in turn, proportional to the recording illuminator voltage. Trace density is also proportional to the time the spot remains in any one position on the photographic emulsion, and this time is inversely proportional to the "spot velocity". Finally, the trace density is proportional to the speed of the emulsion used on the photographic material. Whenever a dynamic signal is being recorded, the galvanometer spot is in motion both across and along the length of the recording medium (time axis). Thus, the true spot velocity is the vector sum of two orthogonal components; (a) the transverse velocity of the galvanometer spot, and (b) the velocity of the recording media (record speed). For the majority of recordings, the second component is sufficiently small in comparison to the first so that it may be safely neglected.

B. WRITING SPEED VERSUS ILLUMINATOR VOLTAGE

The maximum writing speed of a recording oscillograph is the maximum galvanometer spot velocity that will produce a recorded trace of some specified density and a given illuminator voltage. Other variables enter into the determination of maximum writing speed, two of the major ones being the developing procedure and the definition of a given trace density. Fig. 4:02 shows the recommended illuminator voltages for different writing speeds and recording media.

C. ESTIMATION OF MAXIMUM SPOT VELOCITY

In order to determine the maximum spot velocity to be recorded, something must be known about the magnitude of galvanometer spot deflection as a function of time. In many cases this relationship is known approximately and can be sketched roughly on a sheet of graph paper. The spot velocities and points of interest can then be estimated graphically from this sketch.

If the galvanometer current, and, consequently, the spot deflection as a function of time, is sinusoidal, then the maximum spot velocity can be readily determined as follows:

If the spot deflection x (inches) is varying sinusoidally at frequency, f, (cycles per second) with a peak single-amplitude deflection, A, (inches) then

$$\text{Spot deflection} = x = A \sin (2\pi ft) \text{ inches}$$

$$\text{Spot velocity} = dx/dt = a\,(2\pi f)\cos(2\pi ft) \text{ inches per second}$$

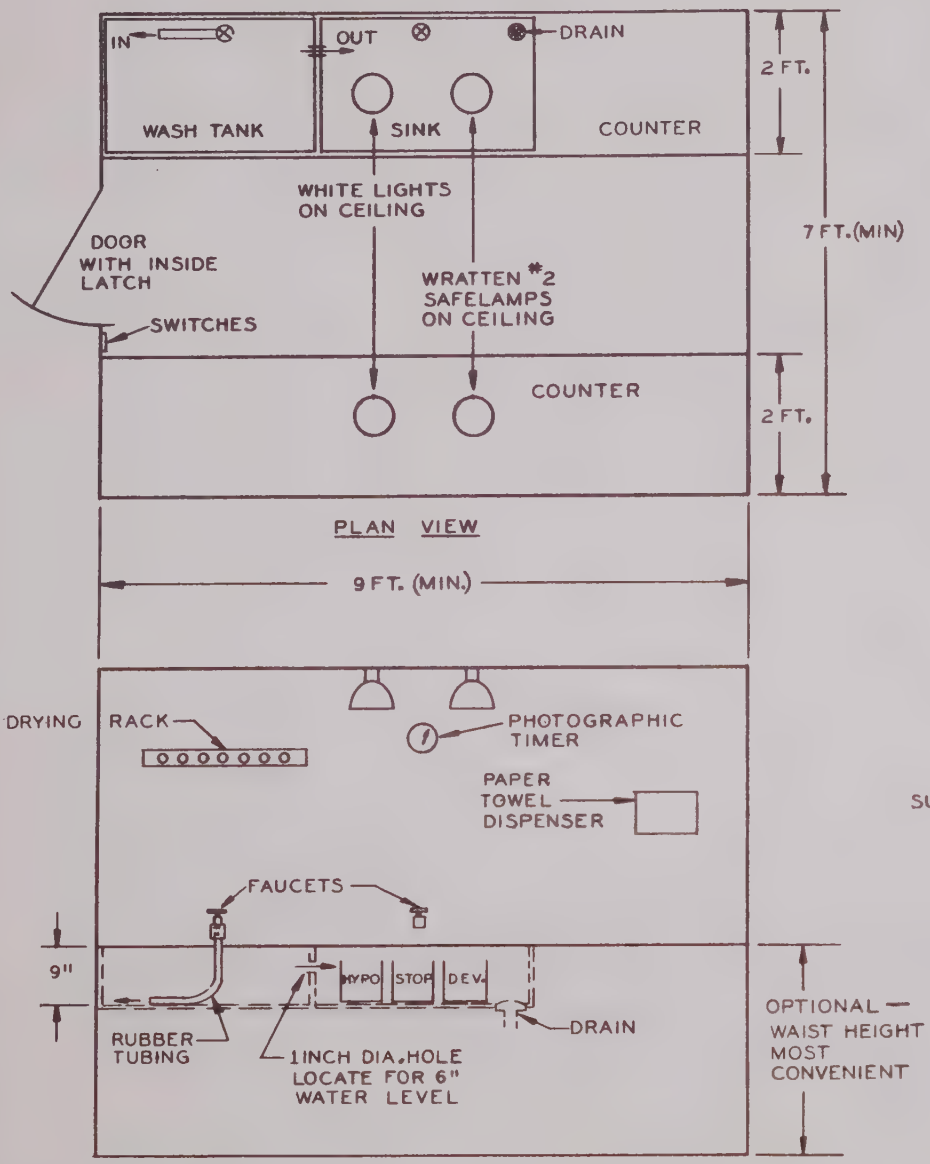
$$\text{Maximum spot velocity} = V_s = A(2\pi f) \text{ inches per second}$$

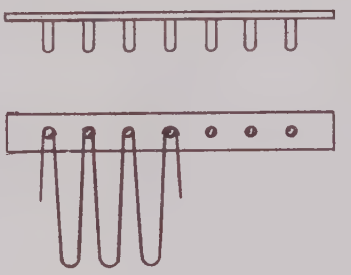
A nomograph of the last equation (Fig. 4:04) relates to maximum spot velocity, amplitude, and frequency. This chart is exact only for pure sinusoidal waveforms, but will give close approximations as long as the harmonic content is low in the case of complex harmonic waveforms.

D. SELECTION OF RECORDING MATERIAL AND ILLUMINATOR VOLTAGE

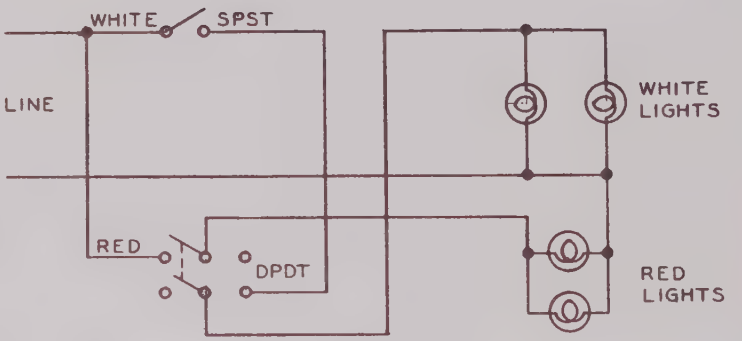
The following procedure is recommended for selection of the recording material and determination of the correct recording illuminator voltage:

DARKROOM LAYOUT





SUGGESTED PEG RACK FOR DRYING RECORDS. RECORDS SHOULD BE HUNG CAREFULLY SO THAT THE EMULSION DOES NOT STICK BETWEEN LOOPS. SPACE PEGS APPROX. 6 INCHES APART.



SUGGESTED LIGHTING CIRCUIT

SUGGESTIONS:

1. COUNTER TOPS SHOULD BE FORMICA, VARNISHED MASONITE, OR OTHER WEAR AND MOISTURE RESISTANT MATERIAL. STORAGE FACILITIES MAY BE ADDED AS CABINETS UNDER THE COUNTERS. SPACE OVER THE COUNTERS SHOULD BE KEPT FREE.
2. WALLS SHOULD BE A LIGHT COLOR TO INCREASE VISIBLITY.
3. FOR ADDED SAFETY, PARTICULARLY IN LARGER INSTALLATIONS, A RED LIGHT MAY BE PLACED OUTSIDE THE ROOM AND WIRED TO BE TURNED ON AUTOMATICALLY WHEN THE DOOR IS LATCHED, THUS INDICATING THAT THE ROOM IS OCCUPIED.
4. TANKS FOR DEVELOPER, STOP BATH (IF USED), AND FIXER SHOULD BE APPROXIMATLY 9 INCHES WIDE, 20 INCHES LONG, AND 7 INCHES DEEP TO AFFORD SUFFICIENT SPACE FOR HANDLING AND THOROUGH CONTACT OF PAPER AND CHEMICALS. LIDS SHOULD BE PROVIDED TO PROLONG CHEMICAL LIFE. STAINLESS STEEL MEDICAL STERILIZER TANKS WORK WELL FOR THIS PURPOSE.

FIG. 4:01

5-119P4
6-59 2061

1. Determine as closely as possible the maximum spot velocity which is to be recorded.

2. Select the combination of recording material and illuminator voltage which provides sufficient writing speed to record this spot velocity. In this section it is well to keep in mind the following considerations:

a. High voltages drastically reduce the life of the recording illuminator.

b. In general, it is advisable to record the maximum spot velocity as a very light trace so that it will not be too dense when the spot velocity is minimum.

If the spot deflection-versus-time relationship cannot be predetermined, even approximately, it will be necessary to determine the choice of recording material and correct illuminator voltage by trial and error.

3. A wide variety of recording materials is available for use with this oscillograph. The factors which will determine the choice of a particular material will be: length of the record desired, 250, 450, or 475 feet (regular or ultra-thin base paper); transport speed; frequency and amplitude of the trace with highest recording spot velocity; cost of recording material; and method of developing. Recording paper is usually used; however, if copies of the record are desired, film should be used. (Processes now exist for making copies from thin or ultra-thin papers.) A table of the available recording media is given here.

Spec. No. 28 - Emulsion turned in on 2-inch I. D. strawboard core

CEC NO.	MANUFACTURER	TRADE NAME	SIZE	REL. SENS.	BASE
30369	Eastman	Linagraph 809	12" x 250'	10	Paper, normal
31195	Eastman	Linagraph 480	12" x 250'	10	Paper, normal
30371	Eastman	Verichrome Pan Film	12" x 250'	125	Clear acetate
30372	Eastman	Linagraph Ortho Film	12" x 250'	160	Gray acetate
31203	DuPont	Lino-Writ 1 Type B	12" x 250'	6	Paper, normal
39205	DuPont	Lino-Writ 3 Type B	12" x 250'	44	Paper, normal
39206	DuPont	Lino-Writ 1 Type W	12" x 450'	5 1/2	Paper, thin
39207	DuPont	Lino-Writ 3 Type W	12" x 450'	40	Paper, thin
40292	Eastman	Linagraph 483	12" x 450'	10	Paper, thin
40738	DuPont	Lino-Writ 2 Type B	12" x 250'	11	Paper, normal
40739	DuPont	Lino-Writ 2 Type W	12" x 450'	10	Paper, thin
45179	DuPont	Lino-Writ 4 Ultra Thin	12" x 475'	50	Paper, very thin
15571	Eastman	Linagraph 44	12" x 475'	20 - 40	Paper, very thin
15572	Eastman	Linagraph 77	12" x 475'	80 - 160	Paper, very thin

DUPONT LINO-WRIT MARK-970 - $37.00

Additional information on ordering is given in the Spare Parts section of the manual.

Before starting a test run, check to see that the magazine contains enough recording material for the complete record as desired.

E. PROCESSING PROCEDURE

Personal preference, as well as the speed and nature of the phenomena recorded, may demand either darker or lighter traces and timing lines. Developing time can be adjusted to yield records of almost any density required.

1. Recommended Developers

Lino-Writ or Linagraph Developer are especially suitable for paper recording materials. While the normal development period is one minute with full strength solution at 68°F, development may be forced as

NOMINAL GALVANOMETER LAMP VOLTAGE

FOR DIFFERENT WRITING SPEEDS AND RECORDING MEDIA

Writing Speed = $2\pi FA$ F = Frequency in cps A = Amplitude

WRITING SPEED IN/SEC	VOLTAGE FOR MEDIA HAVING A RELATIVE SENSITIVITY OF 10	VOLTAGE FOR MEDIA HAVING A RELATIVE SENSITIVITY OF 40
10	8 1/2	
50	10	8
100	12	9
150	13	10
200	14	10 1/2
250	14 1/2	11
300	16	11 1/2
350	16 1/2	12
400	16 1/2	12
450		12
500		12 1/2
600		13
800		13 1/2
1,000		13 1/2
1,500		14
2,000		15
3,000		15 1/2
4,000		16
5,000		16
6,000		16 1/2

FIG 4:02

long as 5 minutes without danger of chemical fog. This is possible through the antifog agent in this formula, which permits development by inspection to the point where the faintest traces are visible. If standard developers such as D-72 or Dektol are used, developing time should be restricted to the recommended periods for these formulas.

a. Papers

DuPont Lino-Writ, or Kodak Linagraph Developer (full strength) are available in dry form for making five quarts of solution.

b. Film

Kodak D 19 Developer (full strength) is available in dry form for making one or three-and-one-half gallons.

2. Stop Bath

While not absolutely necessary, a stop bath used immediately after the developer will greatly prolong the life of the fixing bath, since it prevents transfer of developer to the hypo. The following formula is recommended:

Water	32 ounces
28% acetic acid	4 ounces

(To make approximately 28% acetic acid from glacial acetic acid, dilute 3 parts glacial acetic with 8 parts water.)

3. Fixing

After the stop bath or intermediate wash, transfer the record to the fixing bath, or hypo. When the bath is fresh, the fixing time should be from 5 to 10 minutes, or 10 to 20 minutes after the fixing bath has been used for any length of time. To insure even fixing, the records should be agitated during the first few minutes in the bath.

To avoid staining, the hypo should be discarded when it becomes cloudy or foamy in appearance. Fresh hypo will have a "bite" when rubbed between the fingers; an exhausted bath will have a soapy feeling and should be discarded.

Acid Fixing Powder with Hardener is packaged in prepared powder form to make 1, 5, and 20 gallons of solution. The Eastman Kodak Company's booklet "Formulas" gives details for those who wish to mix their own solutions.

4. Washing

Records should be washed at least 20 minutes in running water. If records must be examined immediately, they may be partially washed, then dried and examined, and thoroughly washed later, if they are to be kept permanently. Insufficient washing may cause the record to discolor and fade due to the action of the hypo remaining in the paper or film.

5. Drying

Paper or film may be hung to dry on pegs spaced about one foot apart. Only the back of the record should touch the peg, and care must be exercised that emulsion surfaces do not contact each other and stick in drying. A rotating drum dryer of the type used in commercial photo finishing is desirable when

long records or a large number of records must be processed. An ordinary rotating household ironer may be very successfully used for this purpose.

6. Darkroom Layout

Fig. 4:01 shows a simple darkroom layout which will suffice for all but the most intensive program. If running water is not available, development and fixation alone can be darkroom operations, with washing carried out elsewhere.

F. OSCILLOGRAM PROCESSOR

The Consolidated Type 23-109A Oscillogram Processor simplifies handling during record processing and eliminates the necessity for darkroom processing facilities. Transfer of the record from the oscillograph magazine to the processor magazine may be made quickly and easily in subdued light or darkroom, depending on the sensitivity of the recording material used.

Only electrical connections are required for complete operation, as washing has been eliminated from the developing procedure. The processor may be operated in a normally illuminated room or used as a darkroom model with existing darkroom facilities.

Elimination of complex loading and developing techniques permits competent use of the 23-109A by persons having no previous photographic experience.

NOMINAL TIMING LAMP VOLTAGE

FOR DIFFERENT RECORDING SPEEDS AND RECORDING MEDIA

RECORD TRAVEL IN./SEC	VOLTAGE FOR MEDIA HAVING A RELATIVE SENSITIVITY OF 10	VOLTAGE FOR MEDIA HAVING A RELATIVE SENSITIVITY OF 40
0.1	7 1/2	
0.16	7 1/2	
0.25	8	
0.4	8	
0.63	9	
1.0	10	6
1.6	11	6
2.5	11	6
4.0	11	6 1/2
6.3	11	7
10.0	12	7
16.0	13	8
25.0	14	9
40.0	15	12
63.0	16	13
100.0		14
160.0		16

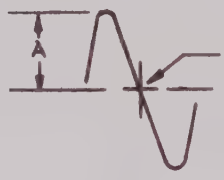
FIG. 4:03

SELECTION OF PROPER TIMING LAMP VOLTAGE

Timing lamp voltage is much less critical than galvanometer lamp voltage because fewer variables are involved. Therefore, after recording medium and record speeds have been chosen according to the requirements imposed by the nature of the data being taken, the timing lamp voltage may be determined. In the above table, use the voltage in the column for the paper or film opposite the record speed to be used.

Only a few of the available papers and films are listed in the table, but appropriate voltages for others may be judged by their relative tungsten speeds, given in Section III of this manual.

NOMOGRAPH RELATING: AMPLITUDE, FREQUENCY AND MAXIMUM SPOT-VELOCITY FOR SINUSOIDAL TRACES



POINT OF MAX SPOT-VELOCITY V_s

$V_s = 2\pi f A$ WHERE-

f = FREQUENCY OF SIGNAL

$A = 1/2$ PEAK-TO-PEAK AMPLITUDE

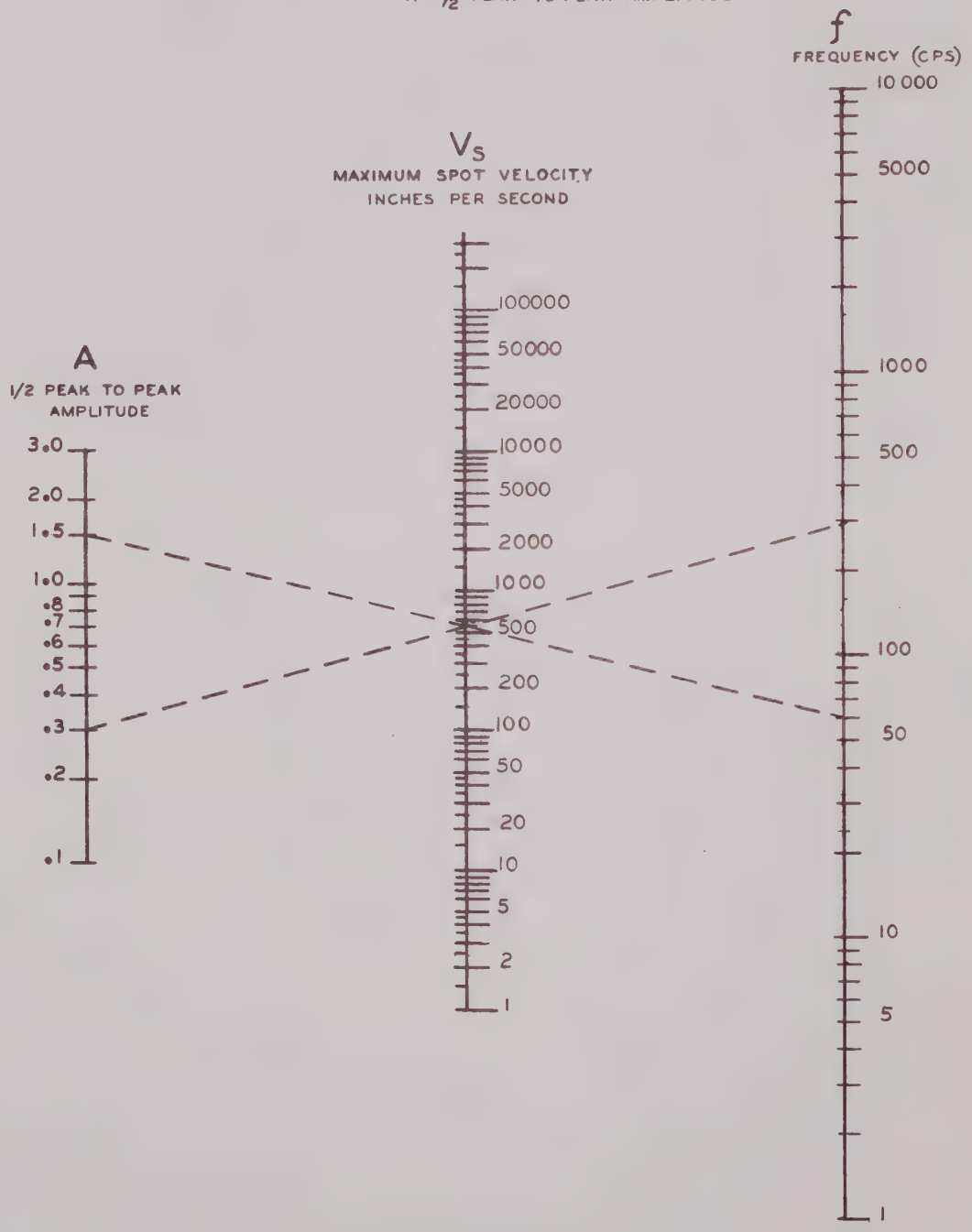


FIG. 4:04

5-119P4
6-59 2061

PART V

OPERATING INSTRUCTIONS

Prior to actual operation, the system must be connected as detailed in Part IX, Schematics. Power must be supplied as given in the Performance Specifications in Part I, Instrument Description. Some accessories may have been incorporated. The galvanometers must have been selected, installed, adjusted, and calibrated in conformity with the information in Part III, Galvanometers.

Considerable time in calculation, fabrication, and testing is required before a system can actually be used for taking precision data. The engineer will select sensing devices, design methods of excitation, of amplification, or attenuation, and determine the damping and mating networks required before he can make a system compatible with the galvanometers he uses, and collect the test information he desires.

Knowledge of operation is required before adjustments and calibration can be started. Adjustments and calibration must be completed before data-taking operation can be started. This manual does not assume to give all information required in this regard; however, it should be studied in detail before the fabrication of a system is completed and data-taking is attempted.

A. PRELIMINARY PROCEDURE

1. Illuminator Tests

a. Recording illuminators

Snap the oscillograph momentarily to RECORD. The galvanometer illuminator brilliance should change to the value determined by the settings of the RECORDING ADJUST VOLTAGE potentiometers, and the position of the JUMP switch on the control unit.

b. Event-numbering flash tube

Remove the magazine. Make a contact closure in the event-numbering circuit between pins "A" and "C" of J-104 on the oscillograph. At the same time, look through the small lens below the left end of the collimating lens. A flash should be observed.

c. Data-numbering flash tube

Snap the oscillograph to and from RECORD. Look through the small lens below the left end of the collimating lens. The flash should come as the switch is moved away from RECORD.

d. Timing flash

Flashes from the slotted disc timing-line system are reflected through the collimating lens from mirror No. 39071. With timing turned on, flashes may be observed in the center of the viewing screen or by looking through the collimating lens. (Fig. 1:01)

2. Recording Speed

Factors to consider in selecting paper speed are: time required to complete the test run, highest frequency phenomena to be recorded, need for copies, and cost of recording material. For runs of considerable duration it may be desirable to use several magazines loaded with fresh recording material. A magazine can be replaced on the oscillograph in a minute or less.

The desired recording speed is obtained by the proper installation of change gears on two shafts. Speed is governed by the transmission-gear ratios as shown on the chart adjacent to the gears. (Fig. 1:04)

Part VI, Adjustment and Maintenance, gives complete details on how to set up for the chosen speeds.

a. Record speed steps

The nominal record speed steps are tabulated below. The SPEED switch position is indicated by the column heading. When this jump speed switch is flipped from LOW to HIGH or vice versa, the speed is changed by a factor of ten; i.e., from the speed in one column to the corresponding speed given in the other column. This change in speed may be made while recording is in progress. Speeds are in inches per second.

.1" - 100"/sec Instruments		.16" - 160"/sec. Instruments	
LOW	HIGH	LOW	HIGH
.1	1.0	.16	1.6
.16	1.6	.25	2.5
.25	2.5	.40	4.0
.40	4.0	.64	6.4
.63	6.3	1.0	10.0
1.0	10.0	1.6	16.0
1.6	16.0	2.5	25.0
2.5	25.0	4.0	40.0
4.0	40.0	6.4	64.0
6.3	63.0	10.0	100.0
10.0	100.0	16.0	160.0

3. Maximum Recording-Spot Speed

The maximum speed at which any galvanometer spot will move across the recording material will be a major factor in deciding what recording material to use. It may also be a factor in deciding what maximum deflection to use in recording the channel involved, and must be considered in setting the voltage to be applied to the galvanometer illuminator during recording. The brilliance of the illuminator serving each of the two banks of galvanometers is set independently. It may therefore be advantageous to record channels involving high-frequency phenomena from one bank, and record channels involving lower spot speeds from the other bank of galvanometers.

4. Adjust Recording-Lamp Voltages

Having determined the greatest speed at which any spot will move and selected a suitable recording material from the table in Part IV, Recording Materials, find the required voltage for each recording lamp. The magazine should be removed to prevent wasting recording material.

a. Have the oscillograph set to POWER ON.

b. Set the control unit JUMP switch to HIGH.

c. Set the oscillograph to RECORD.

d. Depress and adjust the left potentiometer, on top of the oscillograph, to bring the meter to the voltage indication required for the left recording illuminator.

e. Adjust the voltage for the right recording illuminator by use of the right potentiometer.

f. Return the oscillograph to the POWER ON condition, or to OFF.

g. Depressing and turning a potentiometer clockwise increases illuminator voltage. Prior to the time this adjustment is made, it may be well to keep the potentiometers in the full counterclockwise position. These are 11-volt illuminators.

5. Scanning of Waveforms

a. Waveforms may be observed on the viewing screen at the top of the oscillograph. For this purpose, the scan-lens lever should remain in the horizontal position.

b. Push the movable gear to the left for normal scanning speeds or to the right for higher speeds.

c. Speed of the scanning motor may be adjusted within each of the two speed ranges established by the scanning-gear position, by means of the SCAN SPEED knob on the control panel. Cyclic phenomena may be "stopped" on the screen by matching their frequencies with the speed of the polygon mirror while observing the waveform on the viewing screen.

6. Pre-heating of Instrument

The oscillograph should be turned on for a period prior to actual operation, the length of time depending upon the ambient temperature. When the POWER switch is thrown to STANDBY, the block and space heaters are energized to stabilize the internal block temperature at 100°F and thus provide stable galvanometer response when fluid-damped galvanometers are employed. The following table may be used as a guide:

AMBIENT TEMPERATURE	RECOMMENDED HEATING TIME
+60°F	20 minutes
+30°F	40 minutes
0°F	60 minutes

B. LOADING THE MAGAZINE (Figs. 5:01, 5:02)

Loading should be carried out in a photographic darkroom under a suitable safelight, e.g., Wratten Series #2, although, in an emergency, recording papers may be loaded in subdued light. A flat, clear space should be provided for the operation.

1. Place magazine on the shutter side, handle to the front. Remove the cover by loosening the two retaining screws.

2. Remove feed and takeup spools by lifting upward.

3. Remove both right-hand flange ends by pressing on the flat portion of the retaining springs and slipping the flanges from their spindles.

4. Lock both flange stops in the proper position for the width of recording material being used. A locating hole is supplied for standard 12-inch material; holes for other widths may be drilled into the spindle at any desired point. Blind holes are also provided so the flanges may be set to accommodate the following paper widths: 5, 6, 7, 8, and 10 inches.

5. Hold the roll of paper or film so that it unrolls from the top toward the front. Insert the spindle from the left and seat the left-hand flange against the roll. Slide the right-hand flange over the spindle end, and lock in place with the retaining spring.

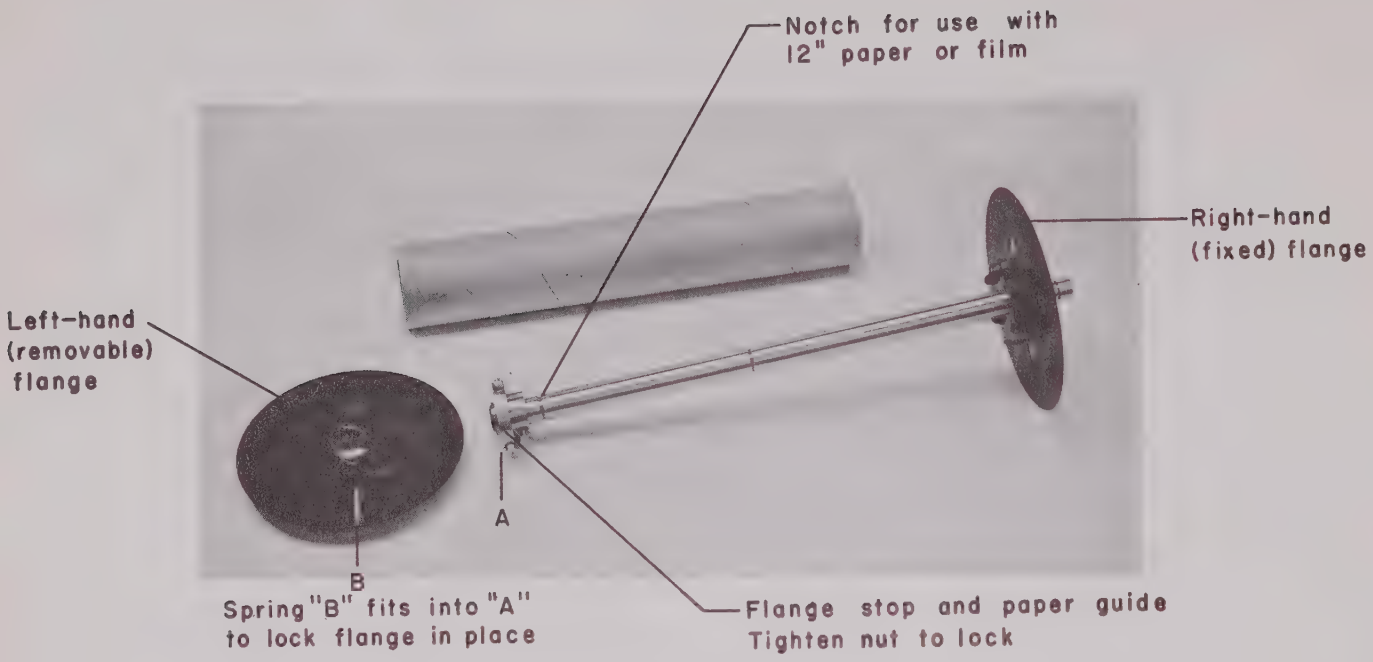


FIG. 5:01
RECORD SPOOL

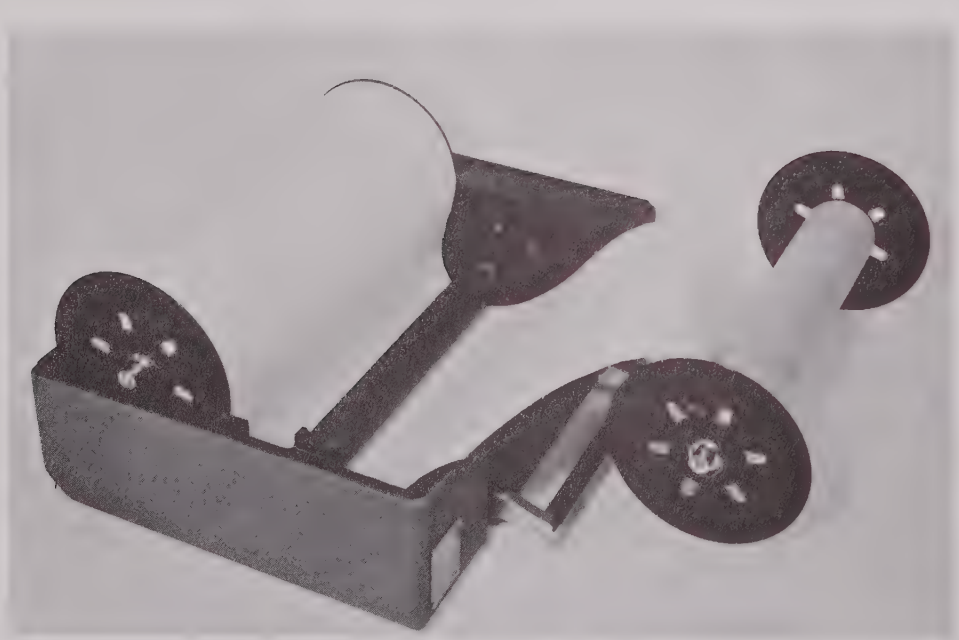


FIG. 5:02
MAGAZINE LOADING

6. Place roll in bearing supports in the magazine in far position, i.e., at opposite side from handle.

7. Insert the spindle and left-hand flange of the takeup reel in a paperboard core of proper diameter.

8. Thread the paper or film, unreeling from top of full roll under the metering roller (Fig. 5:02). This operation is facilitated by cutting end of material in a blunt "V" and bending it into a reverse curve.

9. Place takeup reel in the magazine, center the film or paper between its flanges, and attach to the core with Scotch tape. Wind a complete turn onto the takeup reel to prevent the tape from loosening.

10. Replace the magazine cover and tighten the holding screws by hand. DO NOT USE PLIERS.

NOTE: The path taken by the paper through the magazine and its relation to the oscillograph's optical system is shown in Fig. 1:01.

C. SYSTEM CALIBRATION

With the system properly cabled and grounded and the galvanometer input cables tightly locked in their proper receptacles; with preliminary checks, test and adjustments completed, and with the system left in the POWER ON status long enough for the galvanometer block and electronic circuits to come to a stable temperature, a final system calibration must be made.

Calibration is usually made by applying signals to each galvanometer from the sensing device whose output it is to record. For this purpose the entire system of pickups should be installed and any amplifiers or other auxiliary electronic circuits brought up to operating temperature. The actual test conditions should be simulated as nearly as possible. Each pickup should then be stimulated as it will be during the data-taking run, and the resultant galvanometer-spot deflection may be measured by observing the positions of the streak on the spot-setting screen.

If possible, a calibration recording should be made as a final check for spot positions. This should include no-load or quiescent conditions, as well as the spot deflections resulting when the sensing devices are subjected to regulated and known physical changes. This will give permanent references on the same record as that on which the subsequent data is taken. If test conditions are severe, if battery voltages may decrease, or if transducer or system characteristics are apt to change due to temperature variation or any other cause, it may be advisable to insert recalibration sections into the data record.

D. FINAL CIRCUIT CHECK

1. Check the various controls and indicators on the front panel according to the table in Fig. 5:03. Note operating conditions in effect, or any malfunction.

2. Check the UNEXPOSED SUPPLY INDICATOR of the magazine. Make sure there is enough recording material to complete the desired test.

3. See that the JUMP switch on the control unit is set to HIGH or LOW according to the previously made recording plan.

E. ATTACHING MAGAZINE TO OSCILLOGRAPH

1. Hold magazine with shutter side toward oscillograph, rest two bars at bottom in magazine supports on the oscillograph, push magazine inward until firmly seated, and force handle downward to lock in place.

2. Electrical and mechanical (record-drive) connections are made automatically during the single, continuous operation described in Part I, Instrument Description.

F. RECORDING

1. Start recording by setting the switch in the RECORD position.

a. The white RECORDING indicator (I-109) should burn steadily during recording. Mechanical operation of the oscillograph should be audible.

b. A recheck may be made on the left and right galvanometer illuminators during recording. When the adjustment potentiometer is depressed, the meter will read the recording illuminator voltages as preset.

c. If the NO RECORD illuminator (I-107) comes on, either:

(1) Both MAIN and RESERVE galvanometer illuminators have burned out, or,

(2) The recording paper or film is not moving in the magazine or all the recording material is used up.

d. Event numbers may be put on the record at will by closing the event number switch, if one has been attached to the event-numbering receptacle of the oscillograph.

2. Stop recording by moving the switch away from the RECORD position. The system is ready for immediate resumption of recording.

3. Completely shut down by moving the POWER ON switch to OFF.

G. DEVELOPING THE RECORD

When the magazine is removed, the automatic shutter closes light-tight. The magazine must not be opened until it is taken to a photographic darkroom or other similarly darkened place.

If only part of a roll of material has been exposed, the record may be cut, the takeup spool removed from the magazine, and the core with the exposed roll taken off and developed. A new core must then be installed on the takeup spool before it is returned to the magazine and the remaining record attached to it. The exposed record may be developed and fixed with conventional photographic chemicals as described in Part IV, Recording Materials.

If rapid, on-the-spot, daylight development of the record at the test site is preferred, the use of Consolidated's Type 23-109A Oscillogram Processor is recommended. This automatic equipment, using the modern stabilization chemical process, simplifies and speeds the developing procedure and eliminates the necessity for darkroom processing facilities. It makes the record of the test-run available for engineering evaluation in less than one hour after the run is completed. See Part X, Accessories.

Operating Condition	POWER (switch)	RECORD (switch)	SPEED (switch)	Galvanometer Lamps—Left (control)	Galvanometer Lamps—Right (control)	Timing Lamp (control)	Gear changes	SCAN SPEED (control)	RECORD LENGTH (selector)		Test Warning Lamps (button)	Test Reserve Lamps (button)	Recording (indicator)	No Record (indicator)	No Timing Lamp (indicator)	Reserve Galvo. Lamps (indicators)	Left, Right Galvo. Lamps (indicators)	BLOCK HEATERS (indicator)	Meter (DC volts)
Off	OFF	OFF	(1)	*	*	*	*	*	(2)		*	*	Out	Out	Out	Out	Out	Out	Off
Standby	STANDBY	OFF	—	*	*	*	*	*	—		*	*	Out	Out	Out	Out	Out	(3)	Off
Ready	ON	OFF	—	*	*	*	*	*	—		*	*	Out	Out	Out	Out	On	—	Line
Adjusting Timing and Main Galvo. Lamps	ON	OFF	—	Depressed and Turned	Depressed and Turned	Depressed and Turned	*	*	—		*	*	Out	Out	Out	Out	On	—	Lamp
Testing Reserve Galvo. Lamps	ON	OFF	—	*	*	*	*	*	—		*	Push	Out	Out	Out	On	Out	—	Line
Testing Warning Circuits	ON	OFF	—	*	*	*	*	*	—		Push	*	Out	On	On	Out	Out	On	Line
Recording	ON	Manual or Automatic	—	*	*	*	*	*	—		Immobilized	*	On	Out	Out	Out	On	—	Line
Scanning Only	ON	OFF	—	*	*	*	*	Rotate	—		*	*	Out	Out	Out	Out	On	—	Line
Failure (Record Drive)	ON	Manual or Automatic	—	*	*	*	*	*	—		Immobilized	*	On	On	Out	Out	On	—	Line
Failure (Timing Lamp)	ON	Manual or Automatic	—	*	*	*	*	*	—		Immobilized	*	On	Out	On	Out	On	—	Line
Failure (Main Galvo. Lamp)	ON	Manual or Automatic	—	*	*	*	*	*	—		Immobilized	*	On	Out	Out	On	Out	—	Line
Adjusting Galvo. Traces	ON	OFF	—	*	*	*	*	*	—		*	*	Out	Out	Out	Out	On	—	Line
Changing Record Speeds	*	OFF	—	*	*	*	Change Gears	*	—		*	*	Out	*	*	*	*	—	*

NOTE: CAPITAL letters indicate words or positions on control panel.

* Control inoperative or condition immaterial.

(1) Speed switch may be in either position at any time, depending on record speed desired.

(2) Operative only when RECORD switch is at AUTOMATIC; setting otherwise immaterial.

(3) Intermittent, depending upon instantaneous condition of heater, except in one condition noted.

5-119P4
6-59 2061

FIG. 5:03

PART VI

ADJUSTMENT AND MAINTENANCE

This section of the manual has been written as a guide to normal adjustment and preventive maintenance. Through diligent study of this manual and a conscientious preventive maintenance program, a long life of trouble-free and satisfactory service can be expected from your 5-119P4 Recording Oscillograph.

A. NORMAL MAINTENANCE PROCEDURES

1. Recording Lamps

a. Replacement

(1) Remove the record magazine and recording lamp cover. (Fig. 1:04)

(2) Using the lamp removal tool, press in slightly on the lamp and turn counterclockwise until it is disengaged from the retaining studs, then withdraw it.

(3) Thoroughly clean the surface of the new lamp. Finger marks and dirt will produce "ghosts" on the record. Occasionally, if the lamp has not been obtained from Consolidated's selected stock, one may be found which is impossible to use because of the number of "ghosts" it produces. This is a result of imperfect forming of the glass in manufacture, and the lamp should be discarded.

(4) Replace with the clear side of the glass toward the central partition of the recess. Turn clockwise firmly, making sure that all three studs have been engaged and are snug against the ends of the slots in the lamp-base collar. The lamp has a prefocus base and therefore can be inserted only in its correct position.

b. Adjustments

The quality of the record is dependent upon the galvanometer lamp voltage. The greater the galvanometer-spot velocity (function of the amplitude and frequency being recorded, as well as paper speed), the greater must be the lamp voltage to achieve good definition of trace. Lamp voltages are controlled through the GALVANOMETER LAMPS rheostats LEFT and RIGHT, and the HIGH-LOW SPEED switch, Fig. 1:02. Always start adjustments with the SPEED switch on the LOW position, thus applying the lower voltage range. If sufficient light is not obtained for test purposes by adjusting the rheostat, change to the HIGH position of the SPEED switch. Turn the rheostats fully counterclockwise before throwing the switch to HIGH. The rheostat arm always turns with the knob, but the adjusted voltage is not applied to the lamp and voltmeter unless the knob is depressed. Depression of the knob while turning is necessary to avoid excessive wear on friction locks. During a data run, the lamps will be at the adjusted voltage, but during RECORD - OFF, the applied potential is approximately 10 volts. The operator must conduct his own tests to determine the optimum voltages for his work. If more than 16 1/2 volts are applied, lamp burnout will result.

CAUTION

The galvanometer lamp used in these instruments has a normal rating of 11v, but under certain conditions of operation its normal voltage is exceeded during the recording period. In order to avoid short lamp life, always use the minimum voltage necessary to obtain records of the proper density.

2. Timing Lamp and Timing System (Standard Timing System)

Timing lines are photographed on the record simultaneously with recording by a separate lamp and optical system. In the 5-119P4 Oscillograph, the timing shutter is a disc driven by a synchronous motor, and the accuracy is that of the local power line with respect to 60 cycles per second. A small mirror located in the light path reflects a short bar of light onto the center of the viewing screen to give visual indication of timing system operation.

a. Timing lamp replacement (Fig. 1:04 and 6:02)

(1) With the timing system cover removed, the top of the timing lamp is accessible.

(2) Press the lamp in slightly, turn counterclockwise, and withdraw.

(3) Replace with the clear side up.

(4) Be sure the lamp-base collar is flat against the support and that all three studs are properly engaged. Depress slightly and turn clockwise firmly against the stops.

(5) The timing lamp is identical to the galvanometer lamps.

(6) In the recess beside the timing lamp is a stud, slotted for screwdriver control. To properly position a replacement lamp, observe the intensity of the beam from the timing lamp at the center of the viewing screen and adjust the stud for maximum beam brilliance.

b. Timing lamp voltage

The only factor (aside from lamp voltage) which affects the density of the timing lines is the paper speed, and, therefore, the voltage is not so critical an adjustment as the galvanometer-lamp voltage. Inspection of the records will reveal whether or not adjustment is necessary. The timing lamp is rated 11 volts nominal, and may be varied between 5 and 16 volts. Approximately nominal voltage is recommended.

c. Timing lines

(1) FULL, records timing lines the width of the oscillogram.

(2) EDGE, prints timing lines on each edge of the record.

d. Timing line interval

Two sets of lines are photographed on the record, one heavy and one light. The distance between the heavy lines represents 0.10 sec, and that between the light lines 0.01 sec. When recording at paper speeds of 2 in./sec, or less, it is recommended that only the 0.10-sec timing lines be used. The 0.01-sec timing lines may be eliminated as follows:

(1) Turn the POWER switch off. (Fig. 1:02)

(2) Remove the magazine and timing system cover. (Fig. 1:04)

(3) Turn the timing discs, visible above the timing motor, until the notched portions of their edges are accessible. The lower disc has a small turned-up projection that makes it possible to change its angular position with respect to the upper disc. The lateral motion of this adjustment is limited by projections turned down from the top disc. To print only ten lines per second, move the lower

disc to the right as far as possible with respect to the upper one. This is accomplished by engaging the projections with the thumb and finger nails and pinching them together in the desired direction. Shifting the lower disc to the left restores the 100 lines per second timing. Adjust the lower disc projection only within the space between the stops on the upper disc. If forced to the position where the projections are opposed, the timing lines will not be recorded. The edge of the disc gives considerable leverage with respect to the bearings; therefore, careful handling is in order. Ten lines per second will be recorded when the discs are set as shown in the figure.

3. Flash Tube (Fig. 6:09)

The flash tube registers the record number, the event number, the instrument serial number, and a time arrow on the oscillogram by an intense flash of V-101, the "flash lamp". As a test, the flash may be observed by looking up the opening behind the record-numbering lens holder (Fig. 1:04) and depressing and releasing the record switch. The record-number counter advances at the start of the recording run, but the count is not photographed until the run is completed.

a. Replacement

The flash tube should have very long life. Replacement, when necessary, may be accomplished as follows:

(1) Take off the plate on the left side of the oscillograph, then remove two screws which attach a small inner plate to the record number casting. Integral with the plate is a spring clip that extends under the lamp base and engages a depression on its far side. The lamp base is held in position not only by the clip, but also by considerable friction due to a very snug fit. Work the clip and base loose, and remove as a unit, pulling down slightly, as well as out.

(2) Remove the electric leads after identifying for correct replacement.

(3) Attach the wiring and clip to the new lamp. The lamp and base are an integral unit, and must both be replaced.

(4) Slide the lamp and base in, below the lamp recess, and force up into place, with a snug fit between the base and the casting.

(5) Inspect the wiring for secure connection, replace the clip plate screws and access plate.

4. Record Speed Adjustment

Record speed range is from 0. 16 to 160 inches per second. Some instruments have a record speed range from . 10 to 100 inches per second.

a. Selection of speeds

(1) Remove the record magazine.

(2) Only two gears are used at any speed and they are paired so that an incompatible combination is impossible.

(3) The driven shaft is at the upper left, one drive shaft is below, and the alternative higher-speed shaft is at the right.

(4) The record speeds and gear combinations for each are clearly shown by tables and concentric circles on the panel. Numbers on the gear indicate the number of teeth. HIGH column indicates the record speed when the SPEED switch is positioned at HIGH.

(5) Figure 1:04 shows the gears set for a speed of either 1 or 10 inches per second depending on the position of the SPEED switch (LOW or HIGH).

b. Record speed steps

The nominal record speed steps are tabulated below. The SPEED switch position is indicated by the column heading. When this jump speed switch is flipped from LOW to HIGH or vice versa, the speed is changed by a factor of ten; i.e., from the speed in one column to the corresponding speed given in the other column. This change in speed may be made while recording is in progress. Speeds are in inches per second.

.16" - 160"/sec Instruments		.1" - 100"/sec Instruments	
LOW	HIGH	LOW	HIGH
.16	1.6	.1	1.0
.256	2.56	.16	1.6
.40	4.0	.25	2.5
.64	6.4	.40	4.0
1.0	10.0	.63	6.3
1.6	16.0	1.0	10.0
2.56	25.6	1.6	16.0
4.0	40.0	2.5	25.0
6.4	64.0	4.0	40.0
10.0	100.0	6.3	63.0
16.0	160.0	10.0	100.0

5. Reference Traces

a. Static galvanometer reference trace

(1) One or more reference traces, recorded simultaneously with the data, are required on each oscillogram. (Fig. 1:08). The reference trace is the base line from which each galvanometer deflection is measured throughout the length of the record. By comparison with measurements made on the calibration portion of the record, the true deflection of each trace from its zero or no load position may be calculated. It is recommended that one reference trace be recorded on each edge of the oscillogram. Each mirror should be set approximately straight forward so its reflected beam will be about vertical to the paper, as a trace made at an angle may be excessively wide.

(2) Static Galvanometer Reference Traces Type 7-002 (Fig. 1:03) are used in the 50-trace oscillographs. Two are normally used; one in the galvanometer slot designated L, at the left end of the left galvanometer block, the other in slot R at the right end of the right block. If these positions are used for active galvanometers instead of static galvanometer reference traces, electrical connections may be made through the corresponding L and R plug receptacles on the rear deck of the oscillograph.

Each static galvanometer reference trace has a lens, mirror, and mirror lateral adjustment, but no active coil or electrical connections. The appearance and configuration are almost identical with that of an active galvanometer. Its pole pieces are such that it fits any galvanometer slot, and maintains the same flux pattern as an active galvanometer.

(3) Static reference traces are used on the 36-trace oscillographs, one on each end of each magnet block, making a total of four. Each static reference trace has a focused mirror, and mirror

lateral adjustment, and is attached to its supporting bracket by means of a horizontal pivot. The pivoted mount permits vertical alignment by finger pressure.

b. Dynamic Reference Trace Type 7-004

The Dynamic Reference Trace Galvanometer Type 7-004 consists of a standard CEC galvanometer with smaller pole pieces, which operates on the stray flux at the end of the galvanometer block. (See Part III.) The vertical alignment is factory-set, but the horizontal alignment is similar to that for other galvanometers; therefore, it is used only for gross "on" - "off" signals.

For this reason, the Type 7-004 may be used either as an event marker or as a recorder for external timing pulses. It is valuable for correlating records when several or more oscillographs are multiplexed. The resonant frequency of the Type 7-004 is 3400 cps, its sensitivity 28 milliamperes per inch, and its terminal resistance 47 ohms. Damping is 64% of critical.

The Type 7-004 Reference Trace may be installed in the 36-trace model only; it is attached to the left side of the galvanometer block. The connection is through the receptacle marked DYNAMIC.

CAUTION

Do not apply more than 100 ma to the dynamic galvanometer

6. Shockmount Base #51111

This unit is a heavy-duty shockmount designed for use with the 5-119P4 Oscillograph when the 5-036A Datarite Magazine or 5-032 Crash-Resistant Magazine are used. It is also compatible with the standard 5-006A Magazine.

The #51111 Shockmount absorbs vibratory motion or shocks which may be transmitted by or through the structure on which the oscillograph is mounted. It is recommended that it be used wherever possible. If space does not permit its use, other means should be provided to isolate the instrument from exterior disturbances.

a. To remove the shockmounting base:

(1) Remove the record magazine; turn the oscillograph upside down.

(2) Using a 5/32-inch Allen wrench, remove the fourteen cap screws along the bottom edge of the oscillograph and lift the shockmount off.

(3) The oscillograph may be rack-mounted without the shock base, using the existing tapped holes for the Allen screws. Horizontal mounting with the shockmount on pull-out supports is preferable.

(4) Dimensions are given in Part II, Installation.

7. Air Filter

The air filter is in a panel on the right side of the oscillograph and may be withdrawn upon removal of the retaining screws. It should be cleaned periodically, depending on the dust conditions during operation. The filter may be cleaned adequately with commercial grade kerosene or trichloroethylene.

8. Dust and Moisture

A dust cover is provided with each oscillograph and should be used during storage and inactivity. Under extreme moisture conditions, or if the temperature is below 0°F, remove the cover only while making records.

9. Fuses

Accessible when the record magazine is removed (Fig. 6:10).

10. Relays (Fig. 6:12)

Relays K-101 to K-106 and K-109 are housed in the lower part of the oscillograph. Removal of the oscillograph shockmount exposes the solder connections on the bottom of the relays. Relays K-107 and K-108 are housed in the record lamp housing assembly. To gain access to the solder connections to K-107 and K-108, loosen and swing aside the control panel and the cone-trol assembly immediately under the panel. The relay connection identification drawings, however, are printed on the tops of the relay cans and are not easily visible. The picture shows the relay cans and drawings from above, for assistance in testing and servicing. If malfunction of a relay occurs, replacement rather than repair is recommended.

11. Brushes

The brushes in the record drive motor (2 sets) should be inspected for wear every 500 hours or less. When the brushes have been worn down to 3/8" or less they should be replaced, regardless of their length of time in use. Listed below are the CEC part numbers.

	Maximum Record Speed		RECORD DRIVE MOTOR		BLOWER
			Motor Only	Governor	MOTOR
5-119P4 (5000 rpm	100"/sec	Motor No.	29126	29126-2	39086
110v, 60 cps a-c		Brush No.	29126-1	29126-3	*-----
5-119P4 (8000 rpm	160"/sec	Motor No.	45477	45477-1	39086
110v, 60 cps a-c		Brush No.	29126-1	29126-3	*-----

B. PERIODIC MAINTENANCE

1. Cleaning

CAUTION

Do not use an air hose to clean the oscillograph.

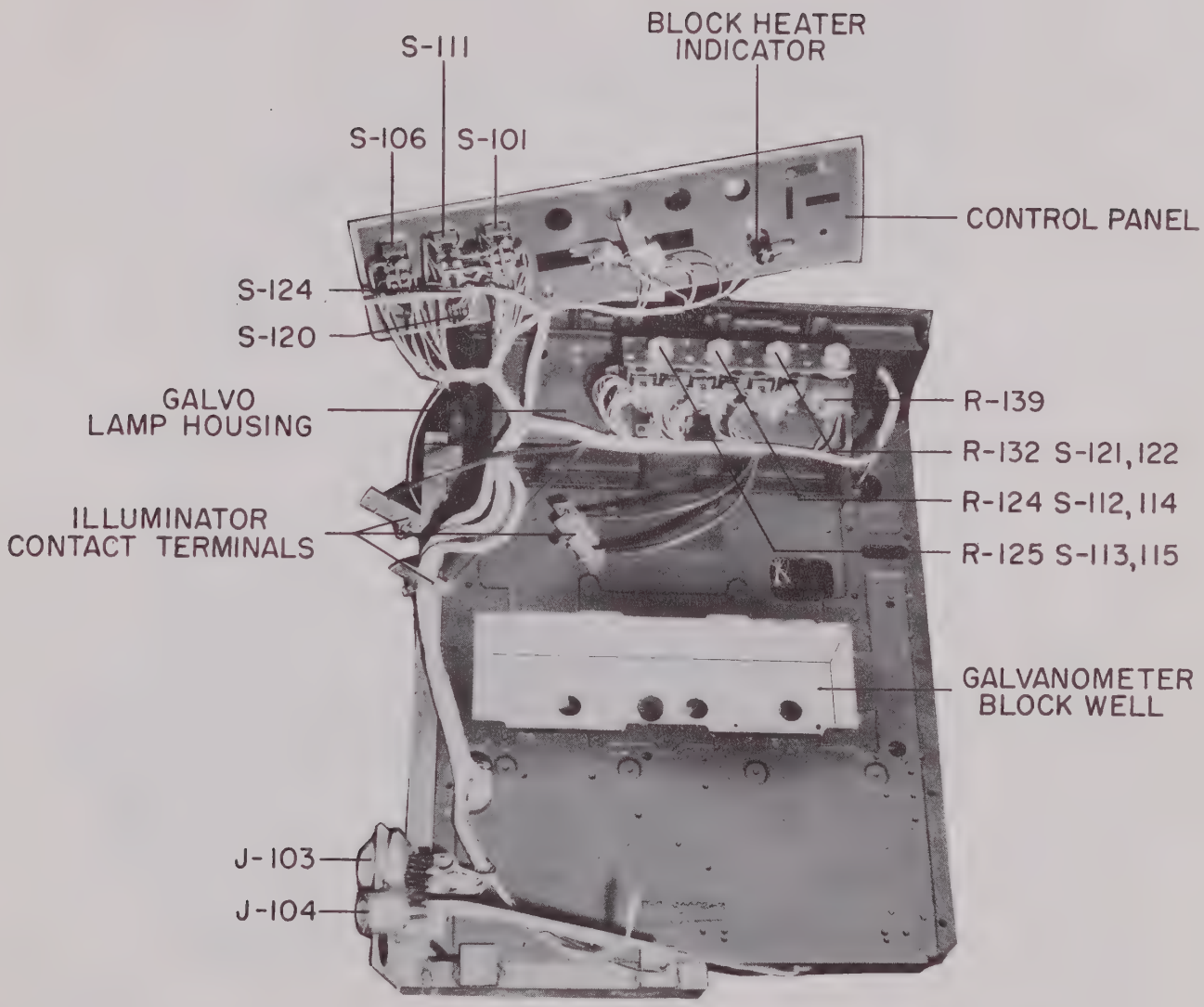
If dust or condensation has accumulated on the optical system to the extent where record quality is impaired, use a light camel-hair brush to remove particles, then swab lightly with cotton saturated with alcohol. It is advisable to disconnect the oscillograph during cleaning. Other surfaces of the oscillograph may be carefully wiped off with a clean cloth.

2. Lubrication - All bushings in the oscillograph and magazine should be oiled every 300 hours of operation. Use SAE 10 engine oil containing no detergent (or equivalent).

3. Belts - Inspect for tension and wear. Adjust or replace as necessary.

4. Parts Inventory - Recheck the stock of operating supplies and essential spare parts.

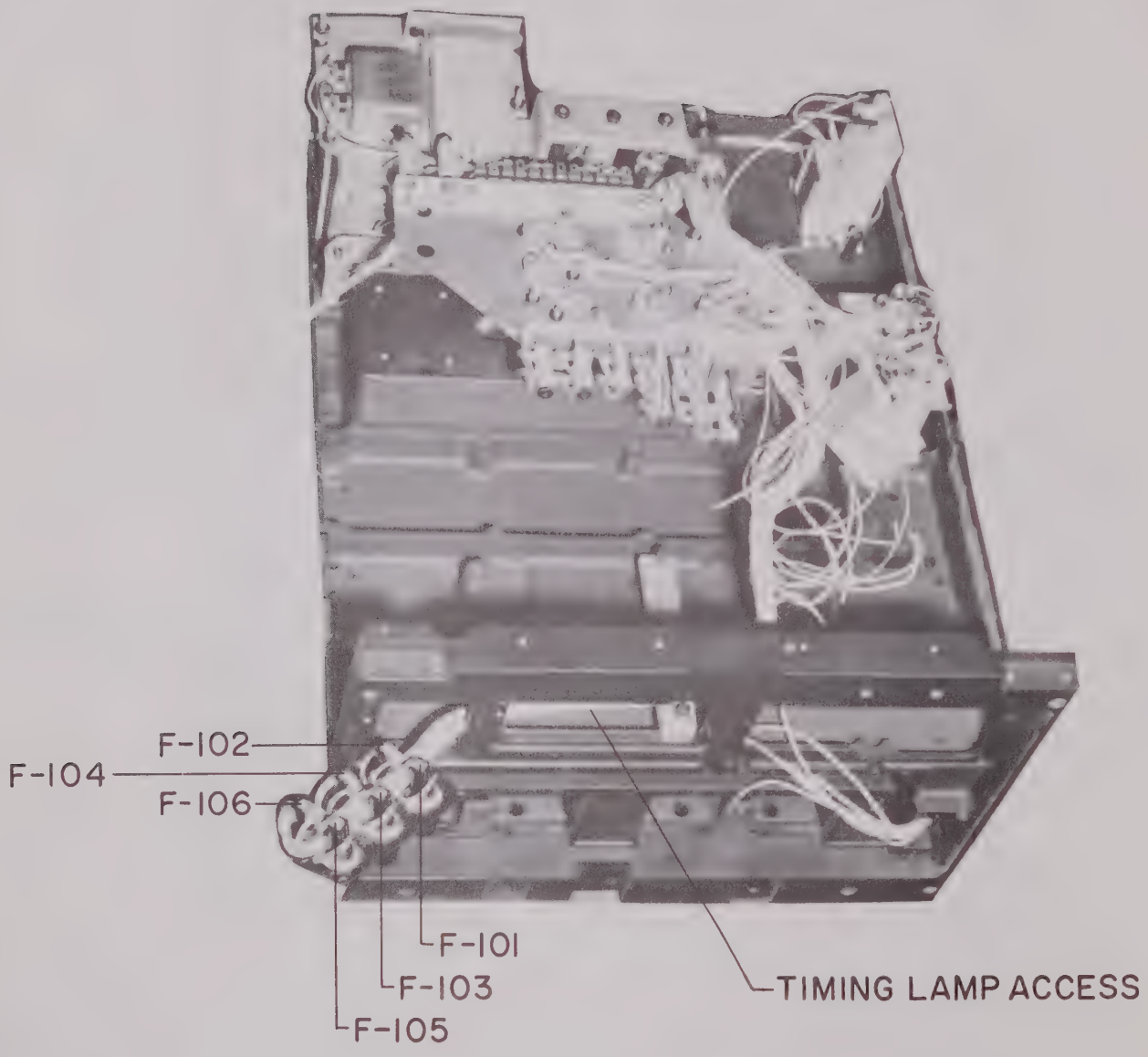
*Induction Motor (no brushes required)



DECK ASSEMBLY TOP VIEW

FIG. 6:01

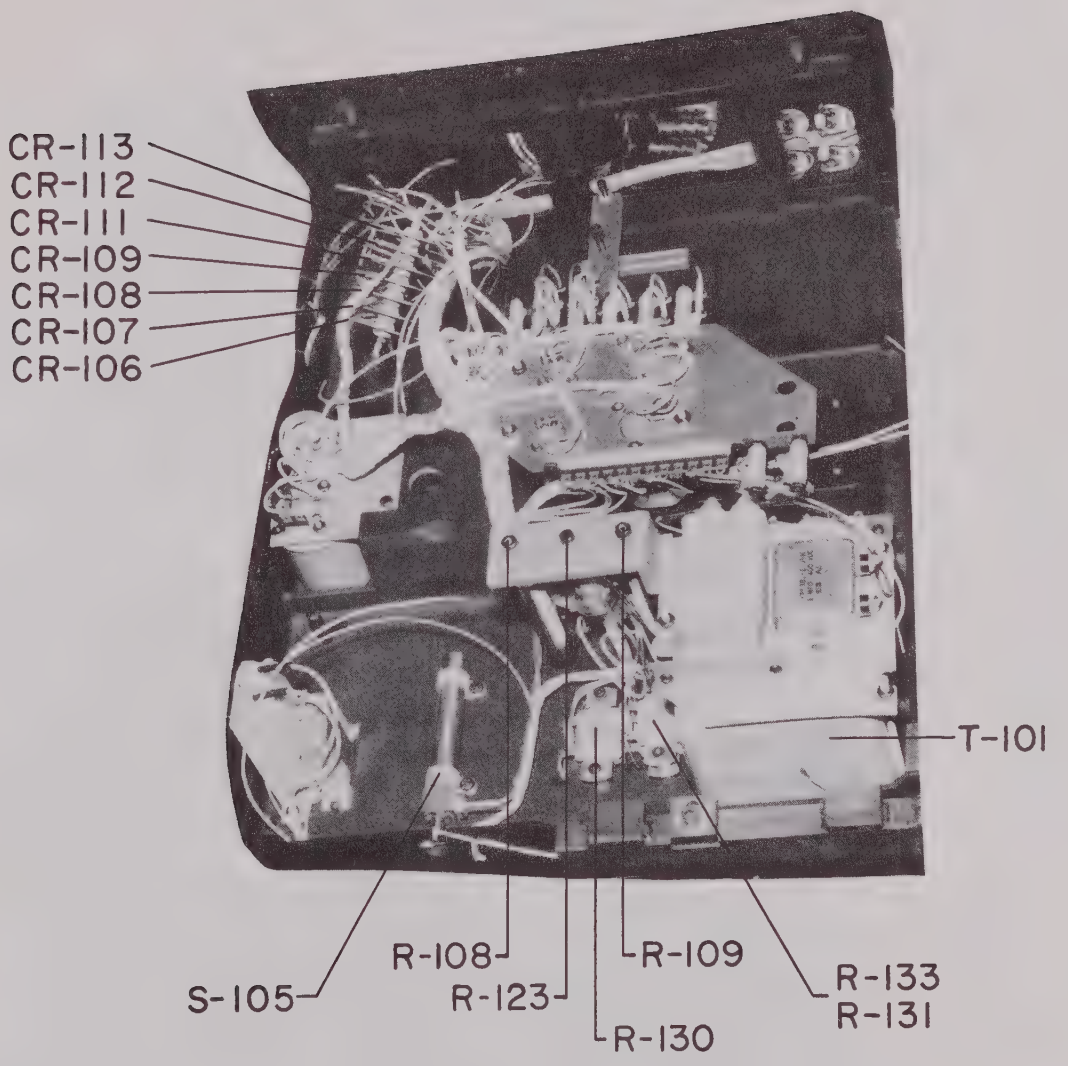
5-119P4
6-59 2061



DECK CASTING – BOTTOM
INCOMPLETE ASSEMBLY

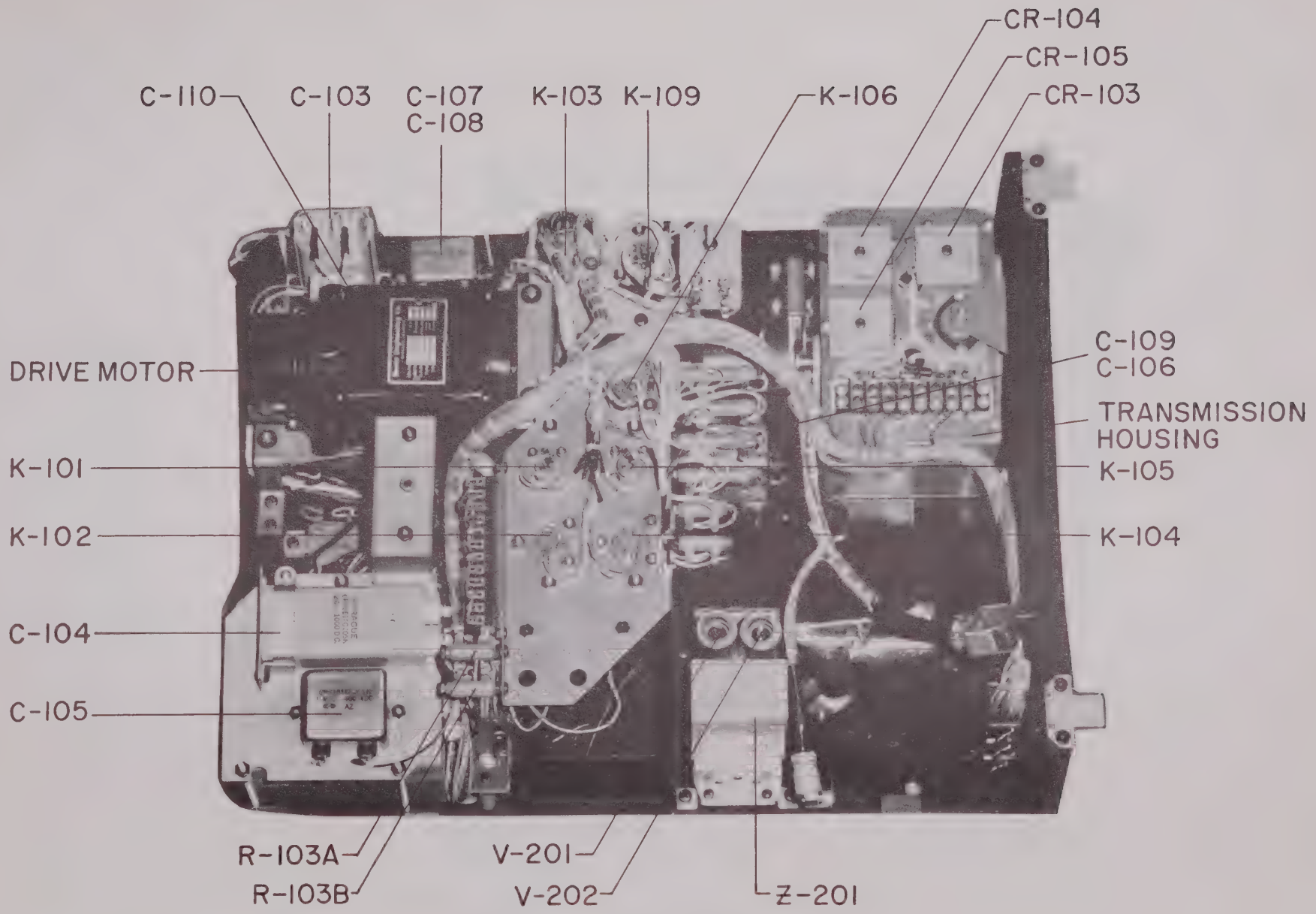
FIG. 6:02

5-119P4
6-59 2061



DECK CASTING - BOTTOM
INCOMPLETE ASSEMBLY
FIG. 6:03

5-119P4
6-59 2061

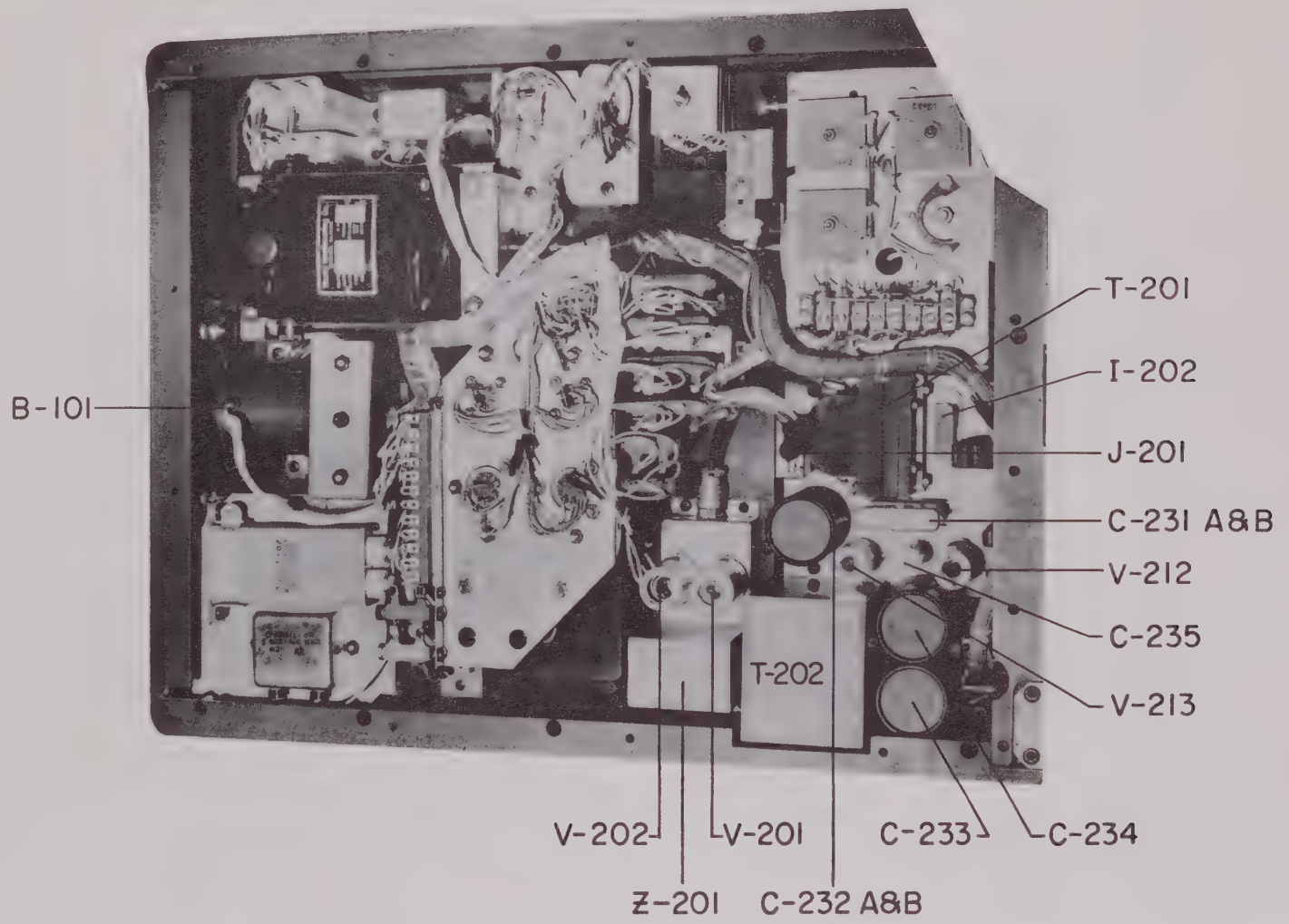


DECK CASTING - BOTTOM
INCOMPLETE ASSEMBLY

FIG. 6:04

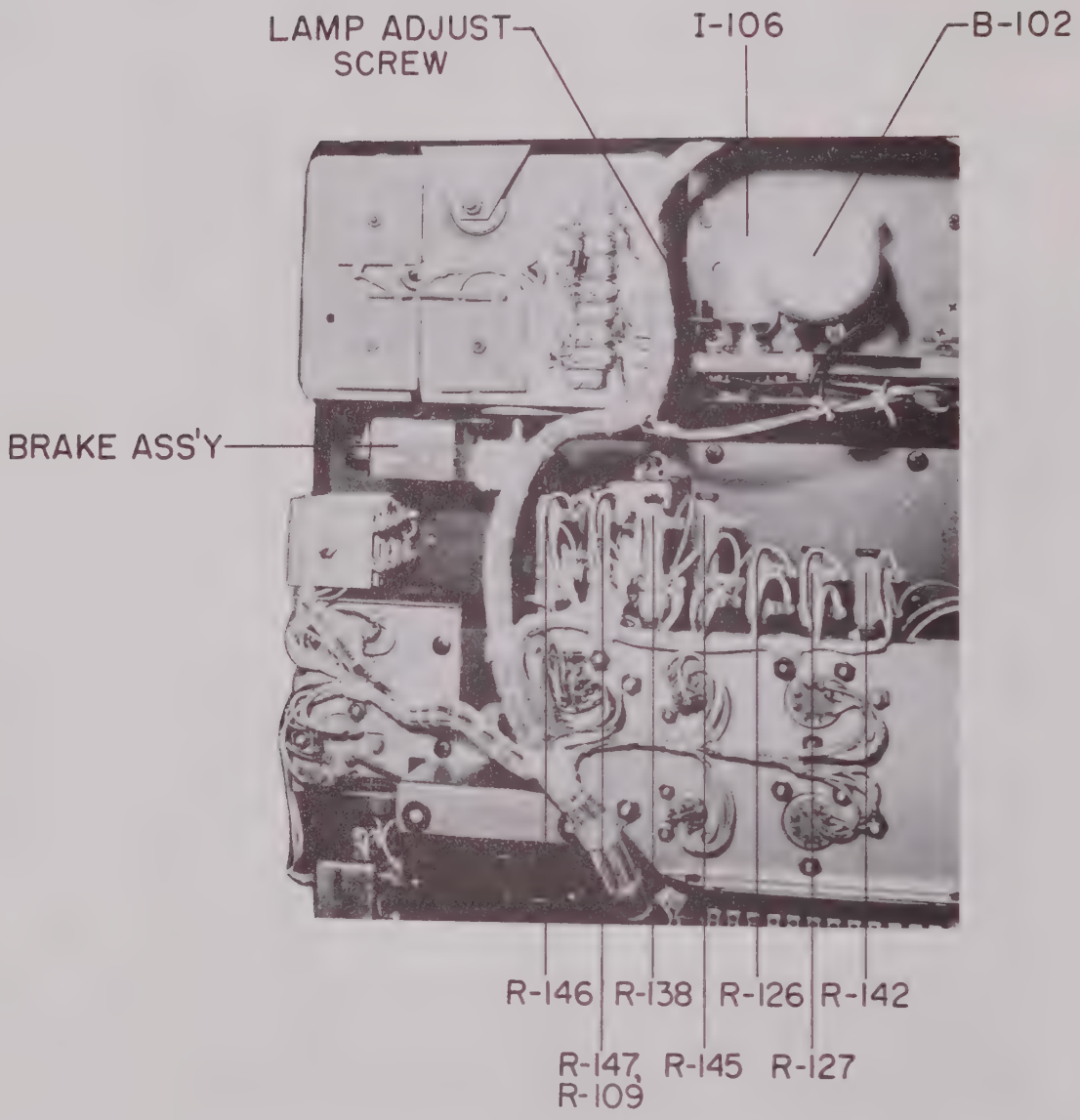
5-119P4
6-59 2061

(ONLY FOR UNITS WITH ELECTRONIC TIMING SYSTEM – SLAVE)



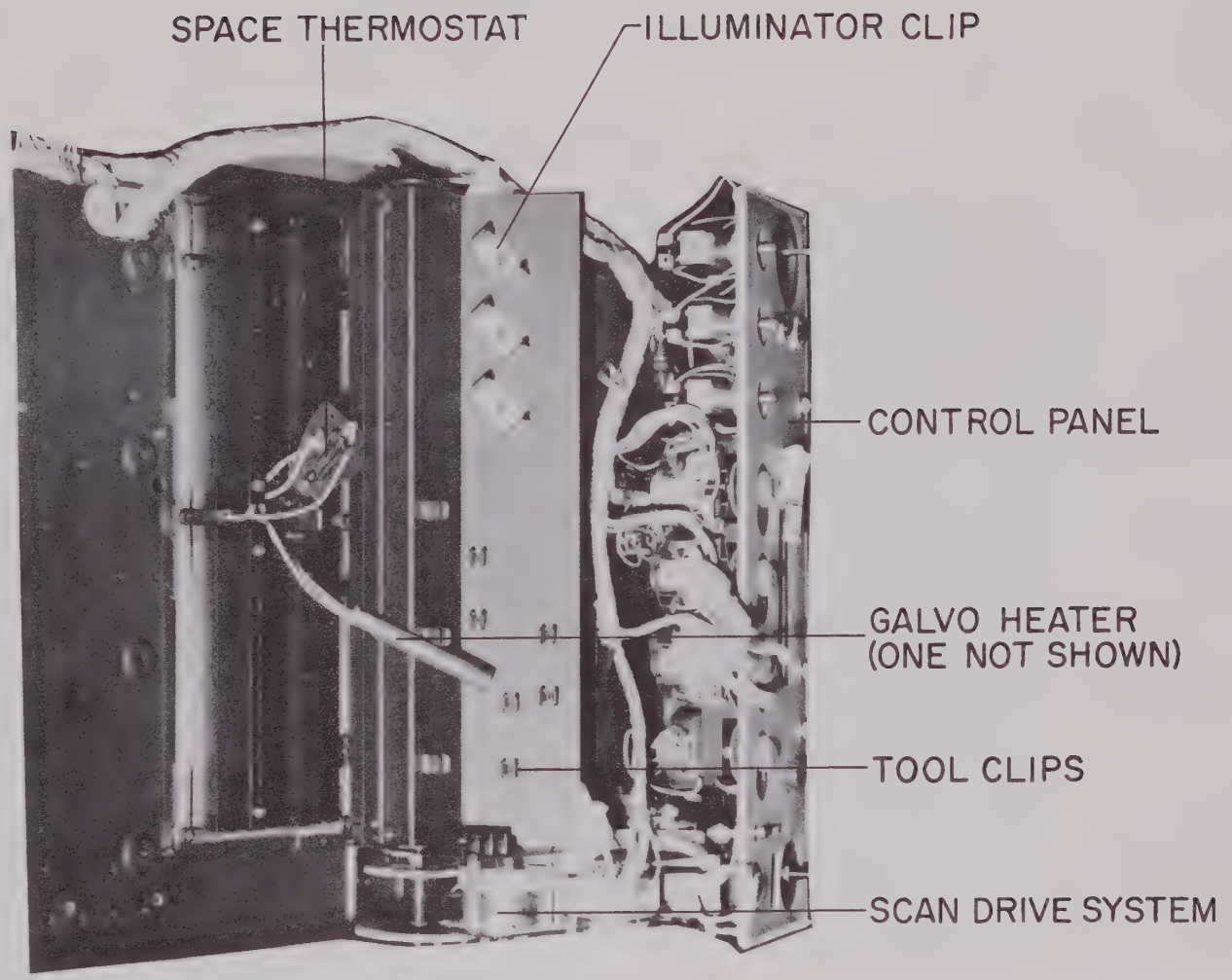
DECK CASTING – BOTTOM
COMPLETE ASSEMBLY

FIG. 6:05



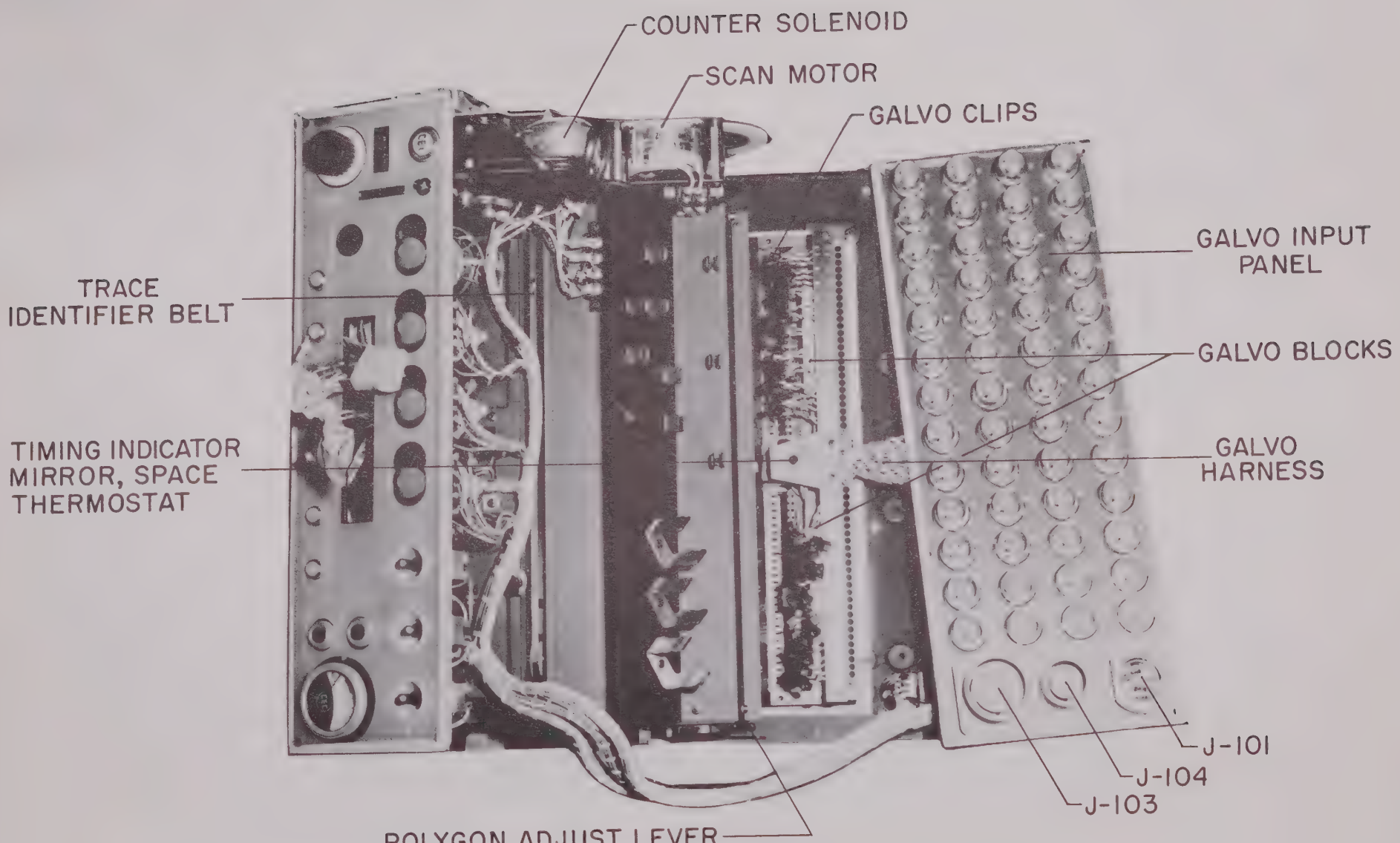
LEFT BOTTOM QUARTER
DECK CASTING - COMPLETE
FIG. 6:06

5-119P4
6-59 2061



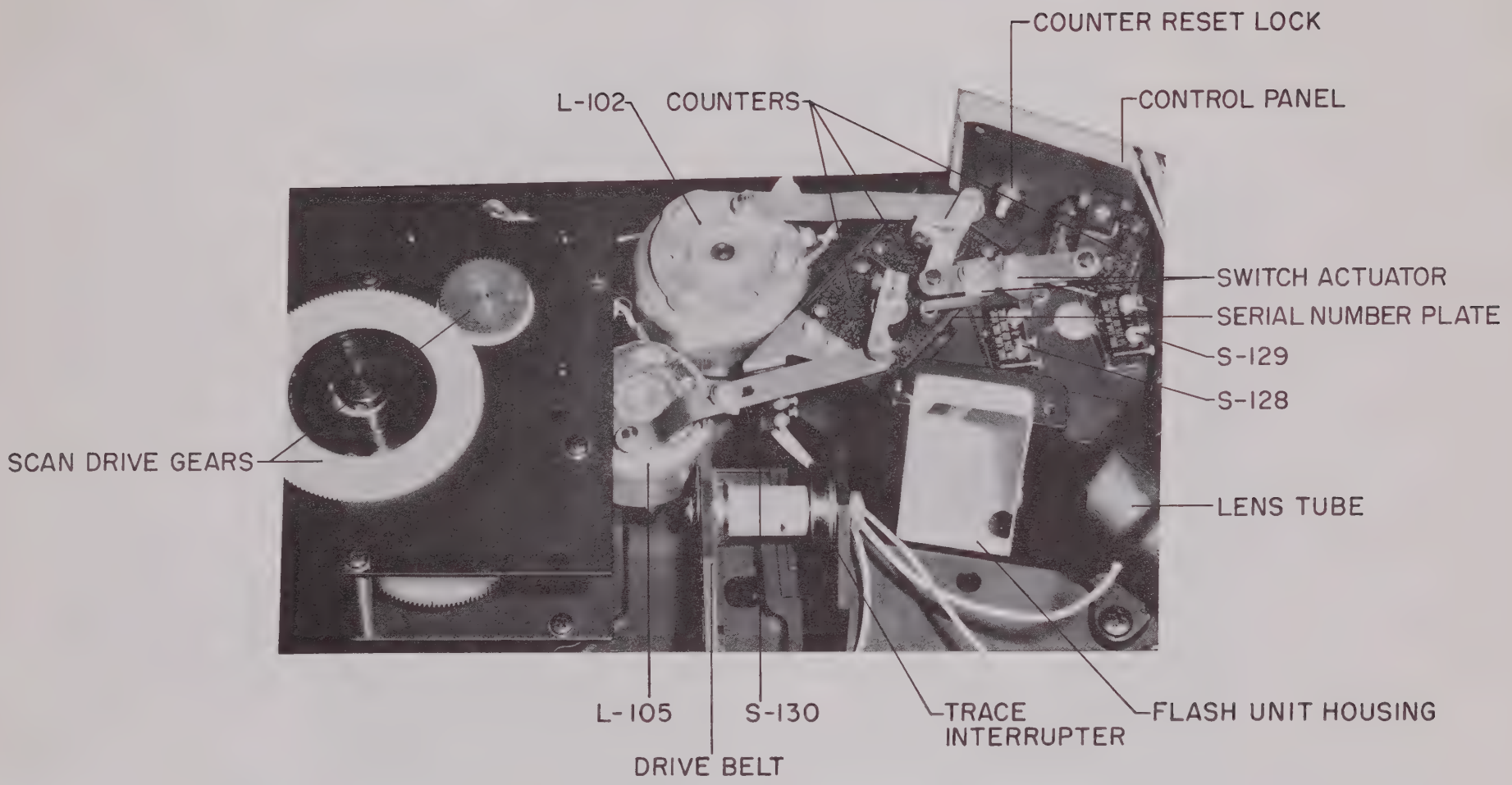
DECK CASTING – TOP
INCOMPLETE ASSEMBLY

FIG. 6:07



DECK ASSEMBLY
TOP VIEW

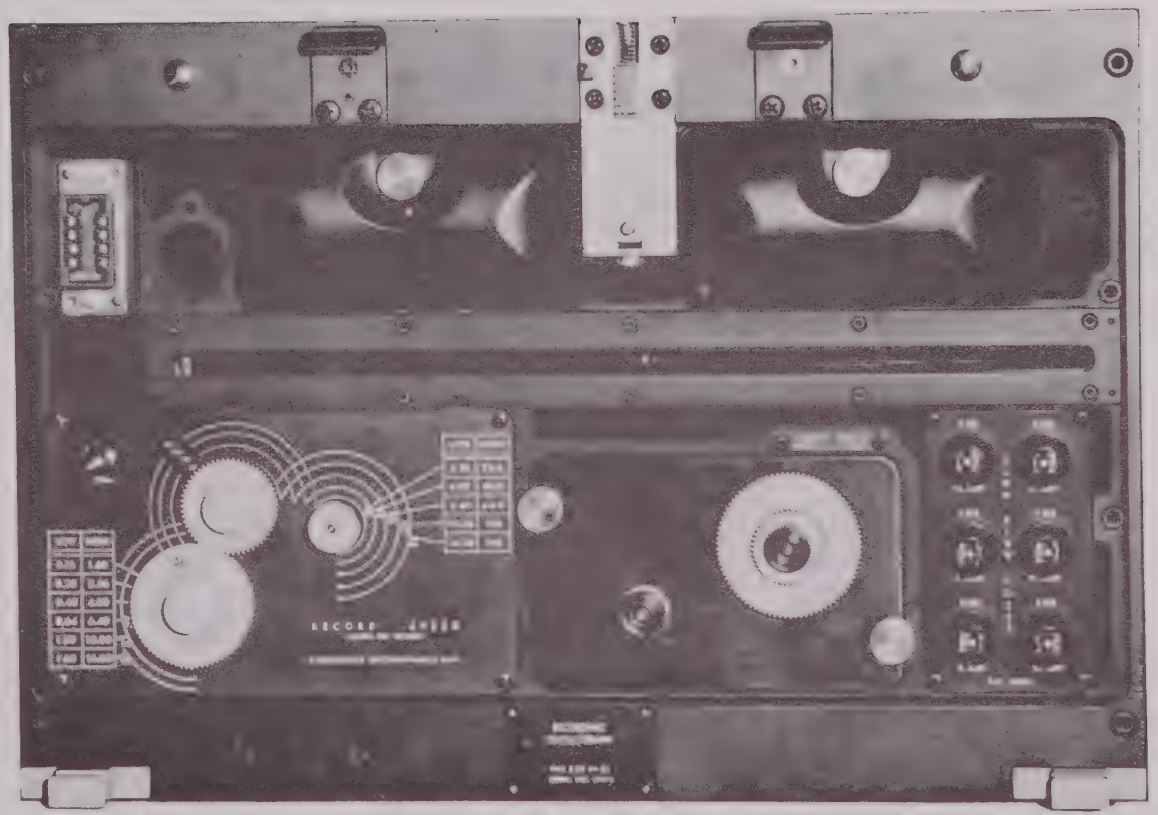
FIG. 6:08



RECORD AND EVENT NUMBER ASSEMBLY

FIG. 6:09

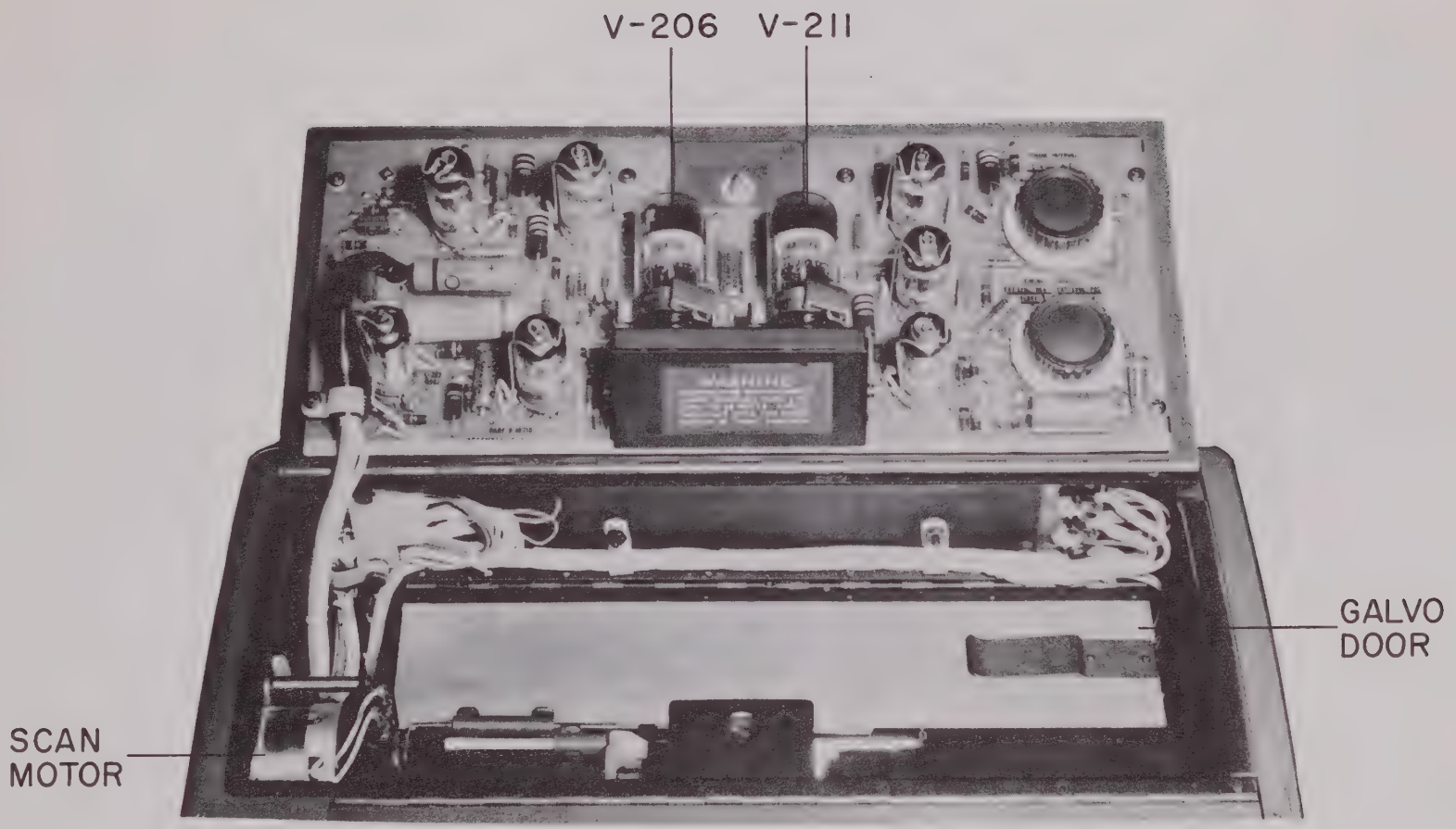
5-119P4
6-59 2061



OSCILLOGRAPH FRONT FACE

FIG. 6:10

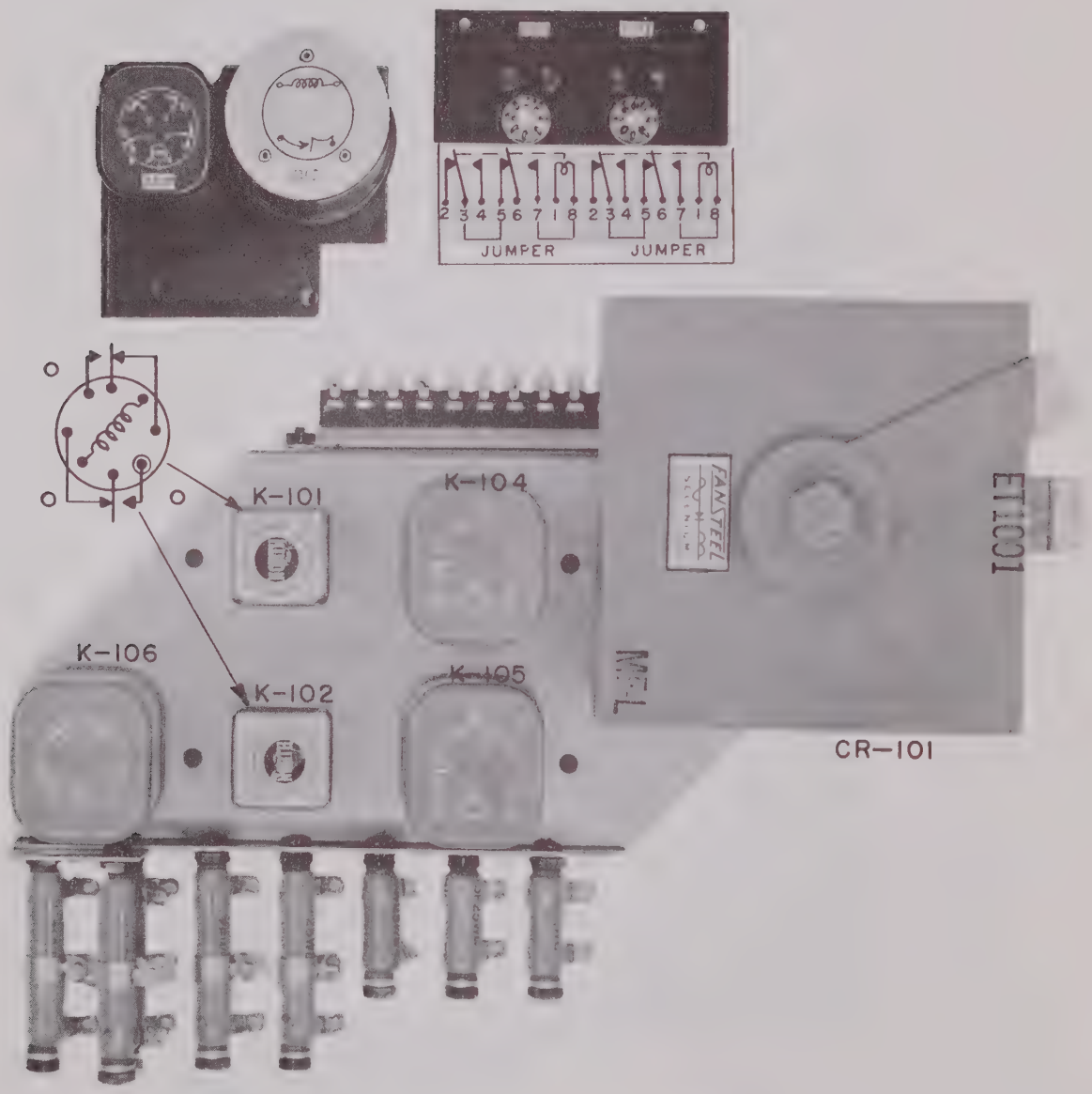
5-119P4
6-59 2061



(ONLY FOR UNITS WITH ELECTRONIC TIMING SYSTEM – MASTER)
COUNTER CONTROL UNIT

FIG. 6:11

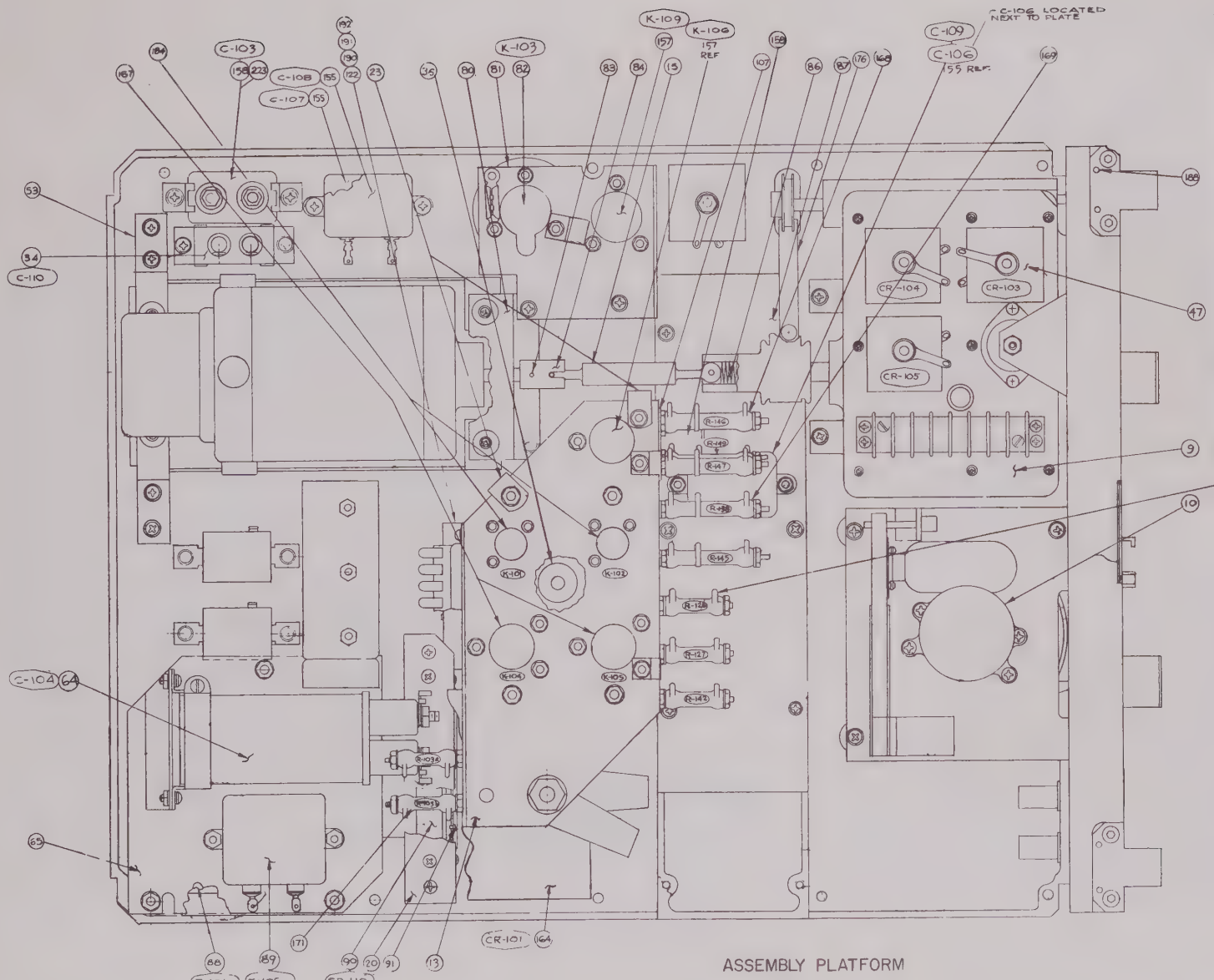
5-119 P4
10-59 2061



RELAY CONNECTION DIAGRAMS

FIG. 6:12

5-119P4
6-59 2061



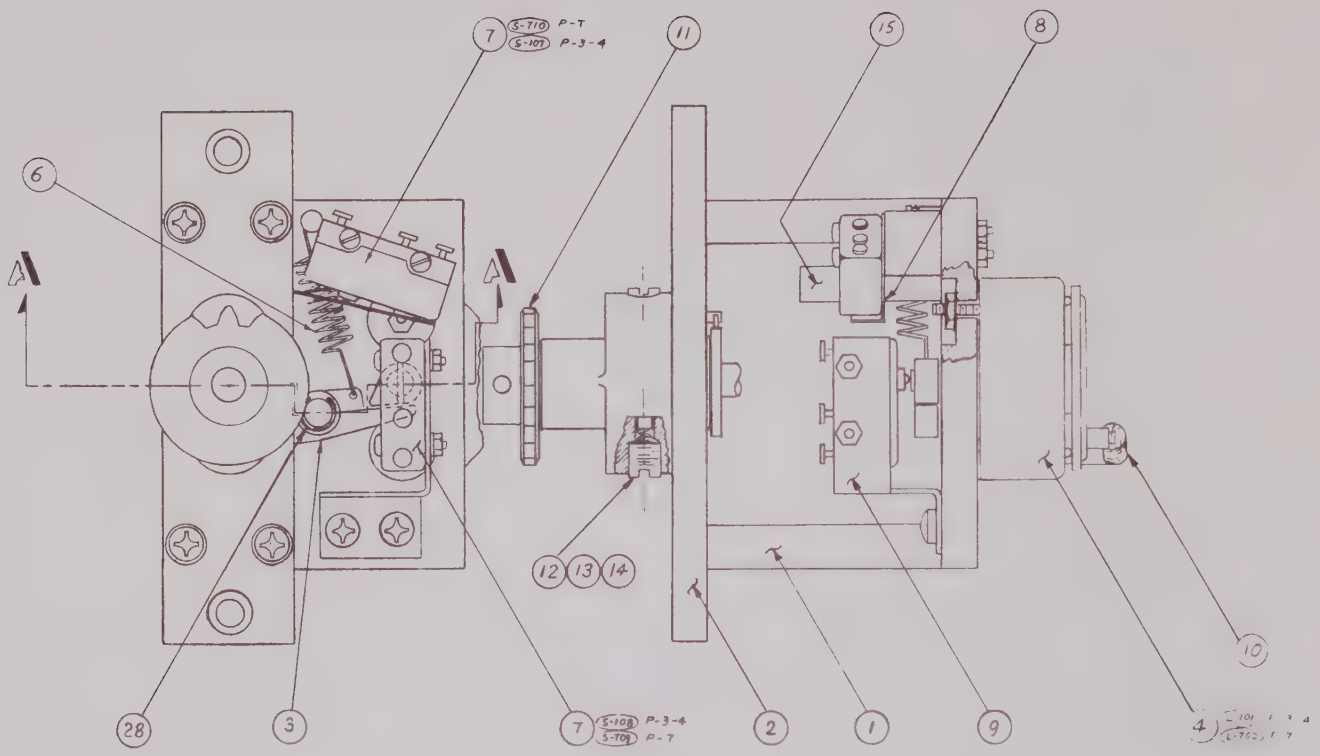
ITEM	DESCRIPTION	PART NO.	NO. REQD.
9	TRANSMISSION ASSEMBLY	43623	1
10	TIMING MOTOR ASSEMBLY	28897	1
13	BRACKET, RELAY MTG	36741	1
15	SHAFT ASSEMBLY	30590	1
20	RECTIFIER MOUNT ASSEMBLY	30261	1
23	CLAMP, CABLE	16786-9	4
34	CAPACITOR -1.0 MFD. 330 V A-C	39109	1
36	GROMMET	6887-23	1
47	RECTIFIER	29824	10
53	MOUNT, DRIVE MOTOR (REAR)	30235	2
64	CAPACITOR, FIXED - 2 MFD 1000 WV	154354	1
65	BRACKET, ASSEMBLY	154631	1
80	BRACKET, MOTOR MOUNT	29588	1
81	BRACKET, MOTOR RELAY	31961	1
82	RELAY	29121	1
83	ROLLPIN 1/8 X 9/16	22628-42	1
84	COUPLING, MOTOR	30360	1
86	SPRING, MOTOR SHAFT	30828	1
87	PLATE, BLOWER MOTOR MOUNT	42338	1
88	TRANSFORMER, POWER	30279	1
89	CAPACITOR - 1 MFD 400 V	35062	1
90	RECTIFIER, SELENIUM	29104	1
91	STRIP, TERMINAL (10)	17252-10	1
107	PLATE, RESISTOR MTG.	33635	1
122	LOCKWASHER, INT #4	7058-45	36
155	CAPACITOR - 10 MFD, 50 W V	29200	4
157	RELAY	29202	2
158	CAPACITOR - 2 MFD, 600 WV	70059-4	1
159	RESISTOR - 7.5 OHM, 10 W	9612-5	1
164	RECTIFIER	36742	1
167	RELAY	29120	2
168	RESISTOR - 10 OHM, 10 W	9612-6	2
169	RESISTOR - 5 OHM, 10 W	9612-4	2
170	RESISTOR - 25 OHM, 5 W	22466-28	3
171	RESISTOR - 10 OHM, 5 W	22466-4	2
176	SPRING, BELT TENSION	34408	1
184	RELAY (NORTH)	33890	2
188	DOWEL PIN - 1/8 X 1/2	7211-30	4
190	TERMINAL STRIP	27025-8	1
191	#4-40 X 1/2 PHIL. BD. HD. M. S.	14050-2665	4
192	FIBRE WASHER	7104-1	4
223	RETAINER, CAPACITOR	70053-4	2

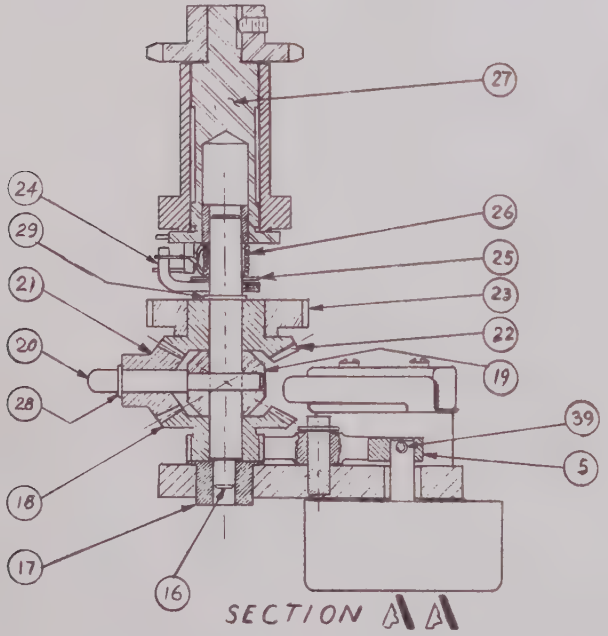
ASSEMBLY PLATFORM

FIG. 6:13

5-119P4
6-59 2061

31468 (REF.)





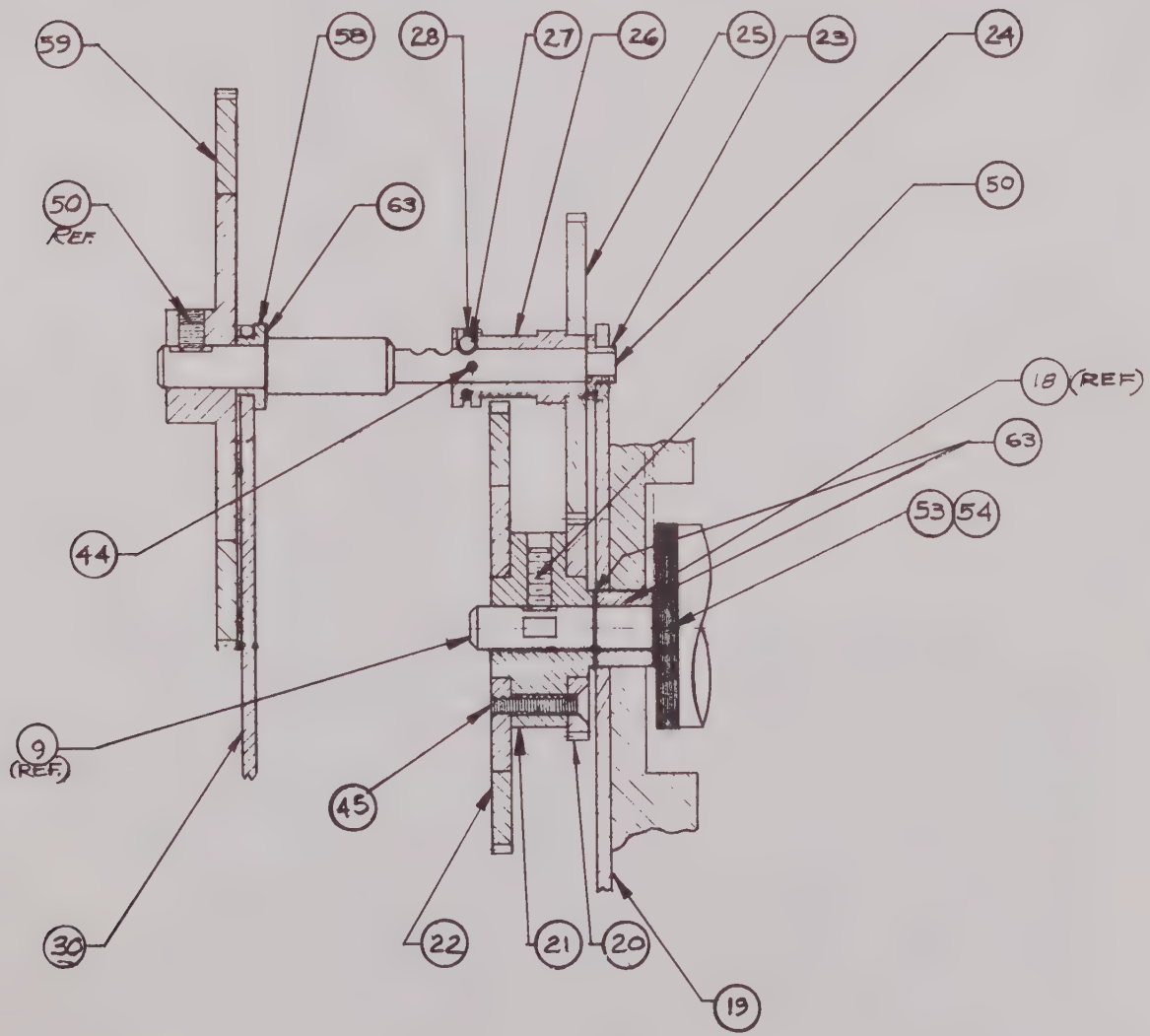
ITEM	DESCRIPTION	PART NO.	NO. REQ'D
1	MOUNTING PLATE	154299	1
2	SLEEVE - PLATE	154301	1
3	LEVER - RATCHET	154302	1
4	ROTARY SOLENOID	29106	1
5	CAM	154310	1
6	SPRING	154309	1
7	MICRO SWITCH	70087-7	2
8	ACTUATOR, MICRO SWITCH	30707	1
9	BRACKET - SWITCH MTG.	33860	1
10	SPRING - RETURN	30013	1
11	SPROCKET	45844	1
12	SCREW - ADJUST	154320	2
13	SPRING DRAG	154308	2
14	PLUG DRAG	29919	2
15	PIN - SHAFT - STOP	32906	1
16	SHAFT - DIFFERENTIAL	29890	1
17	BEARING, FLANGED	30011	1
18	GEAR	154172	1
19	SPACER	29729	2
20	SHAFT-PINION	29723	1
21	BEVEL GEAR (PINION)	7542-2	1
22	BEVEL GEAR	29926	1
23	HELICAL GEAR	29735	1
24	PIN - GEAR STOP	29912	1
25	WASHER	29914	1
26	SPRING - TORSION	30012	1
27	BUSHING ASSY.	154312	1
28	RING RETAINING	24189-4	2
29	RING RETAINING	21891-3	1
39	ROLL PIN 1/16 X 1/4	22628-1500	1

5-119P4
6-59 2061

AUTO RECORD LENGTH CONTROL ASSEMBLY
FIG. 6:14

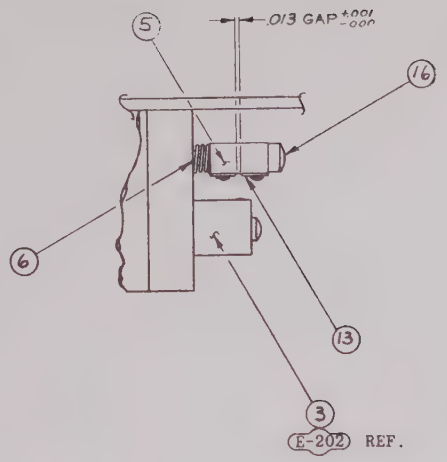
154311 (REF.)

ITEM	DESCRIPTION	PART NO.	NO. REQ'D.
9	SHAFT - POLYGON	30027	1
18	BEARING	25850-3	2
19	PLATE - INNER	30115	1
20	GEAR - SPUR, 60 TEETH	29870	1
21	HUB-GEAR MOUNT	29868	1
22	GEAR - SPUR, 124 TEETH	29871	1
23	BEARING - FLANGED	30325	1
24	SHAFT - GEAR DRIVE	31559	1
25	GEAR - SPUR, 84 TEETH	29869	1
26	GEAR - DRIVE, 20 TEETH	29894	1
27	DETENT - BALL	28443	1
28	DETENT - SPRING	29900	1
30	PLATE - OUTER	29920	1
44	PIN - DRIVE	30326	1
45	2-56 X 7/16 PHIL. FLAT HD. M. S.	14050-1053	2
50	SCREW - ALLEN SET #4-40 X 1/8	19544-101	3
53	BLACK COTTON THREAD	14414	As Req'd.
54	CEMENT - GLYPTOL	17484-15	As Req'd.
58	BEARING - FLANGED	31574	1
59	GEAR - SPUR - 153 TEETH	31537	1
63	WASHER - SHIM	33879	As Req'd.

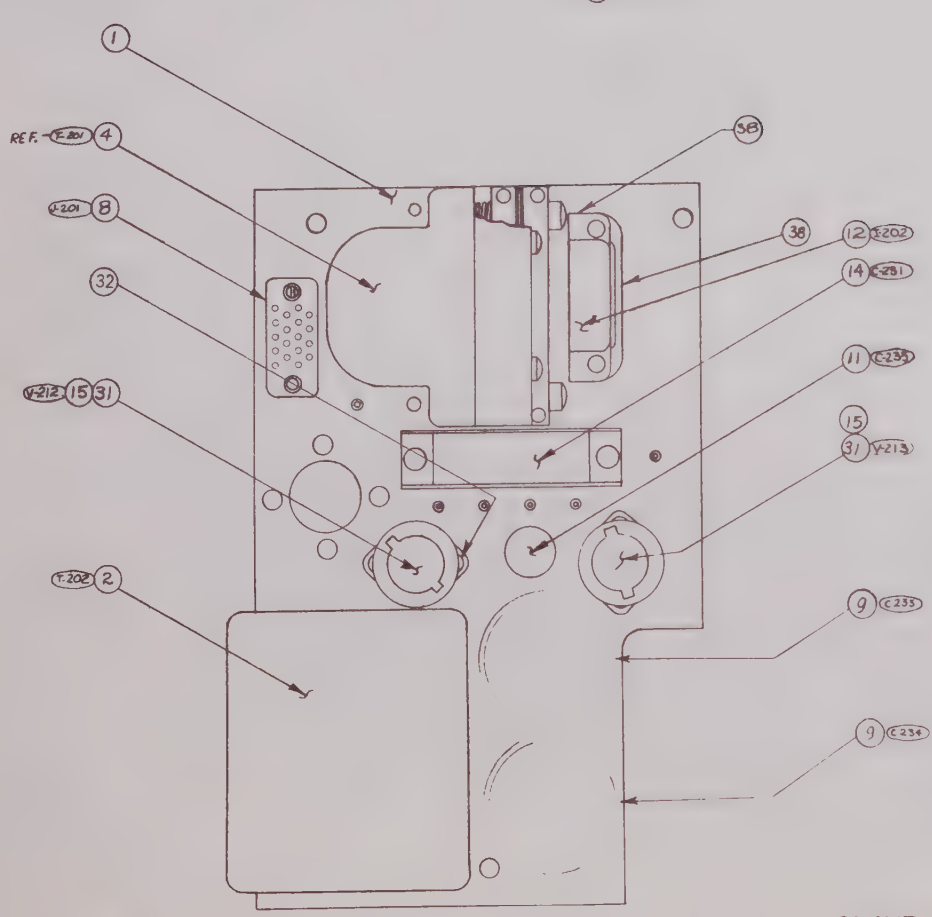


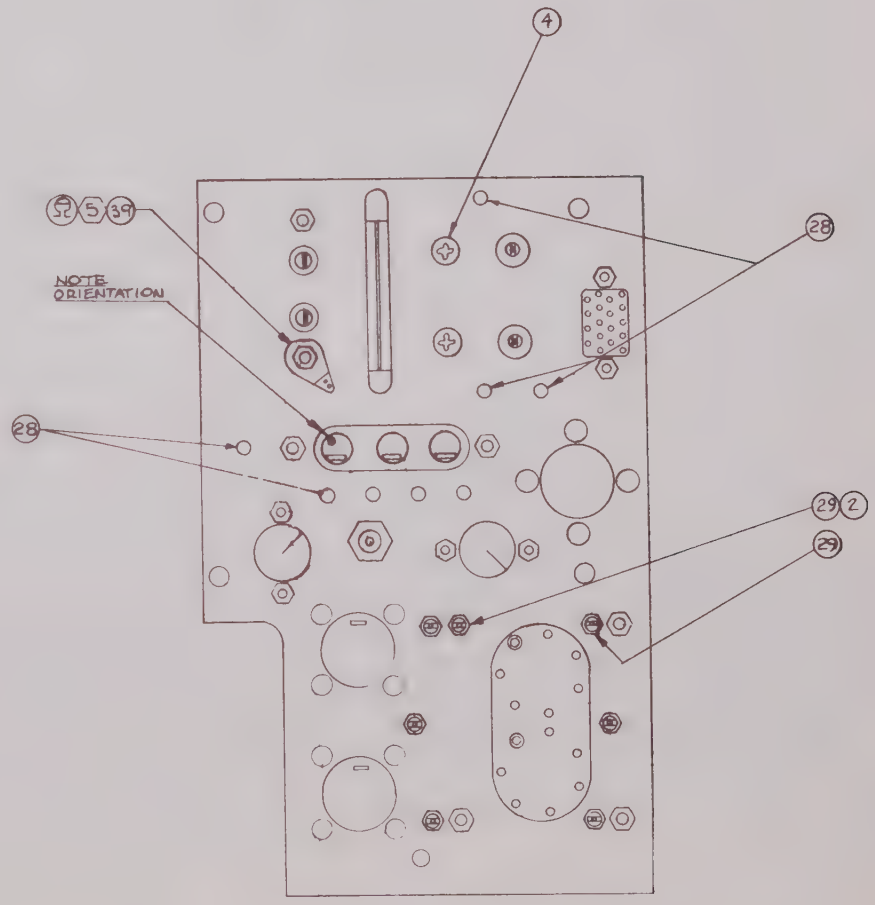
POLYGON DRIVE ASSEMBLY

FIG. 6:15



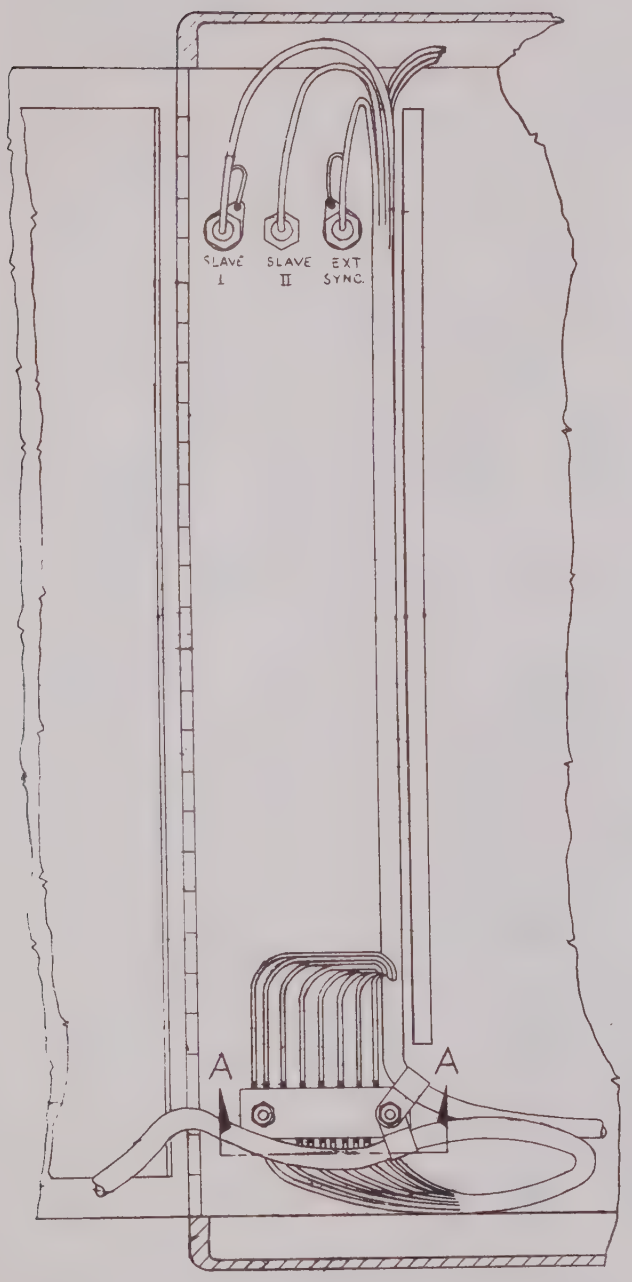
ITEM	DESCRIPTION	PART NO.	NO. REQ'D.
1	HOUSING, TRANSMISSION	51189	1
2	TRANSFORMER, POWER	40888	1
3	FLASH TUBE ASSEMBLY (E-202)	40855	1
4	TRANSFORMER ASSEMBLY (T-201)	40853	1
5	APERTURE, PLATE	40948	1
6	SPRING, COMPRESSION	40515	2
8	CONNECTOR - (PINS) (J-201)	41313-2	1
9	CAPACITOR - 80 MFD, 350 V (C-233, C-234)	40657	2
11	CAPACITOR - 1.0 MFD, 200 V (C-235)	40714	1
12	LAMP INDICATOR (NEON) (I-202)	40854	1
13	APERTURE, STRIP	40594	2
14	CAPACITOR - .25-.25 600 V DUAL (C-231)	41237	1
15	TUBE, ELECTRONIC 2D21W (V-212, V-213)	7016-2D21W	2
16	#10-32 X 1 1/2 PHIL. FIL. HD. MS.	7110-5131	2
28	TERMINAL LUG, TURRET	8118-4	6
29	STANDOFF, INSULATED	14477-6	7
31	SHIELD, TUBE - 7 PIN MIN.	0113-2	2
32	SOCKET - 7 PIN MIN.	70109	2
38	SHIELD, LAMP INDICATOR	49900	1
39	TERMINAL, LUG - SOLDER	7127-8	1

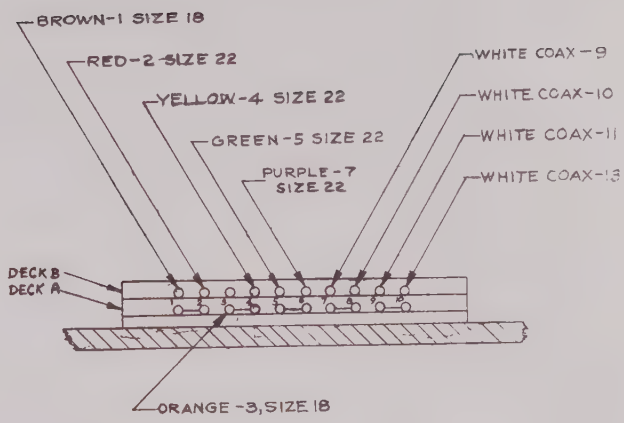




SLAVE UNIT ASSEMBLY

FIG. 6:16



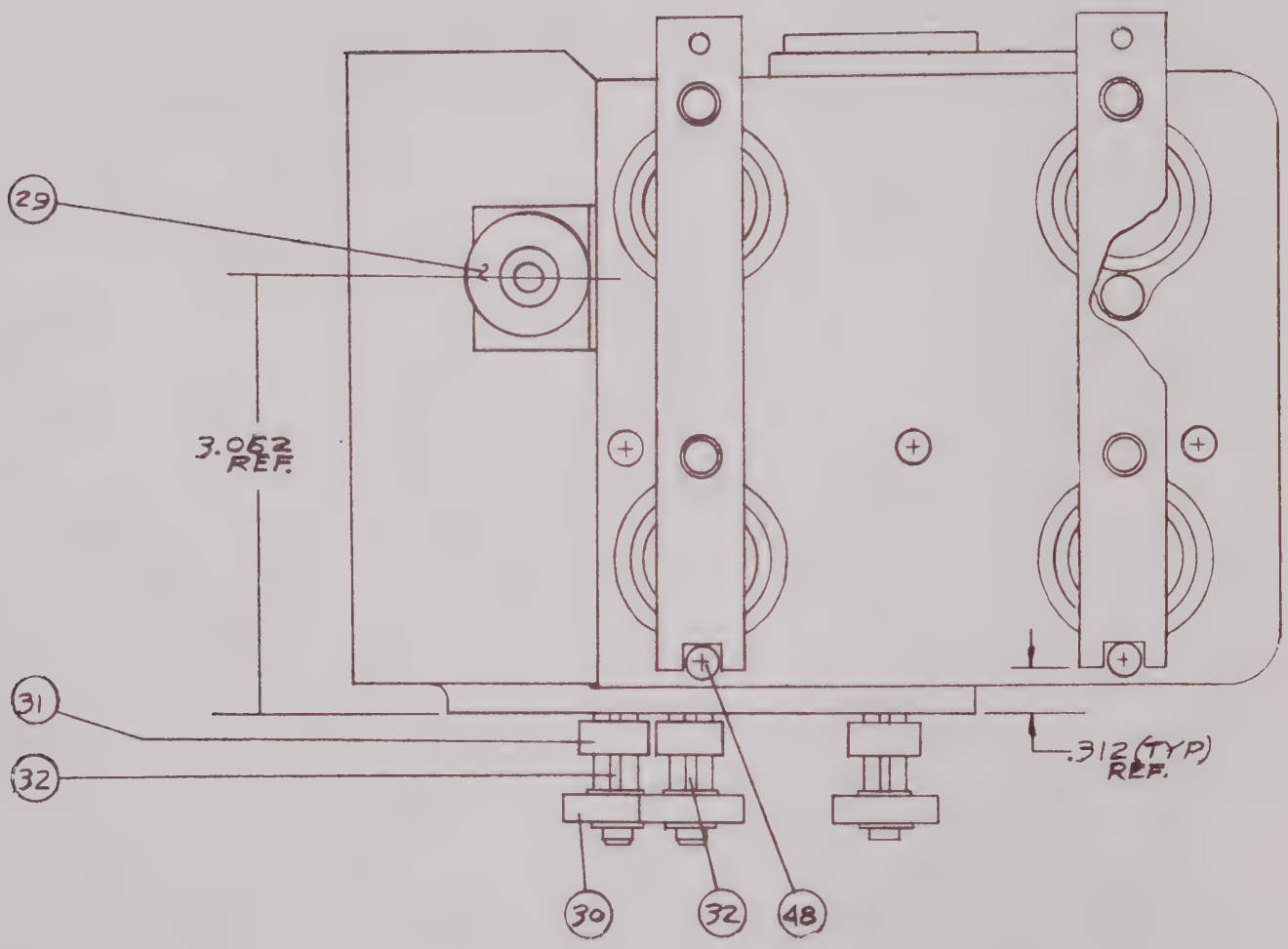


VIEW "A"-"A"

FLASH TIMING HARNESS

FIG. 6:17

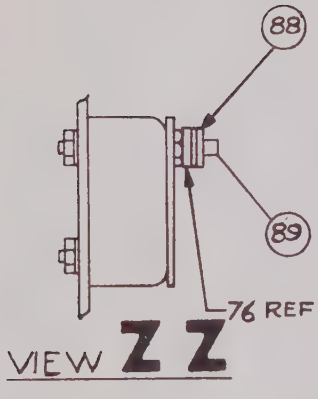
ITEM	DESCRIPTION	PART NO.	NO. REQ'D.
30	NUT, CHANGE GEAR	29696	3
31	RING, SPACER	29754	3
32	KEY, CHANGE GEAR	29818	3
48	SCREW, PHIL. BD. HD. #6-32 X 1/4	7110-3425	13

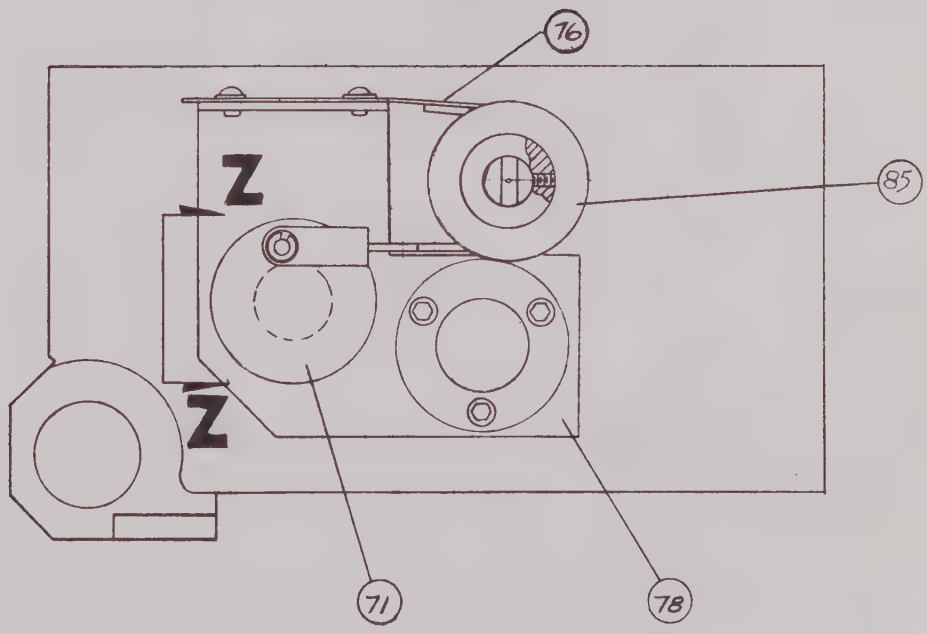


TRANSMISSION ASSEMBLY

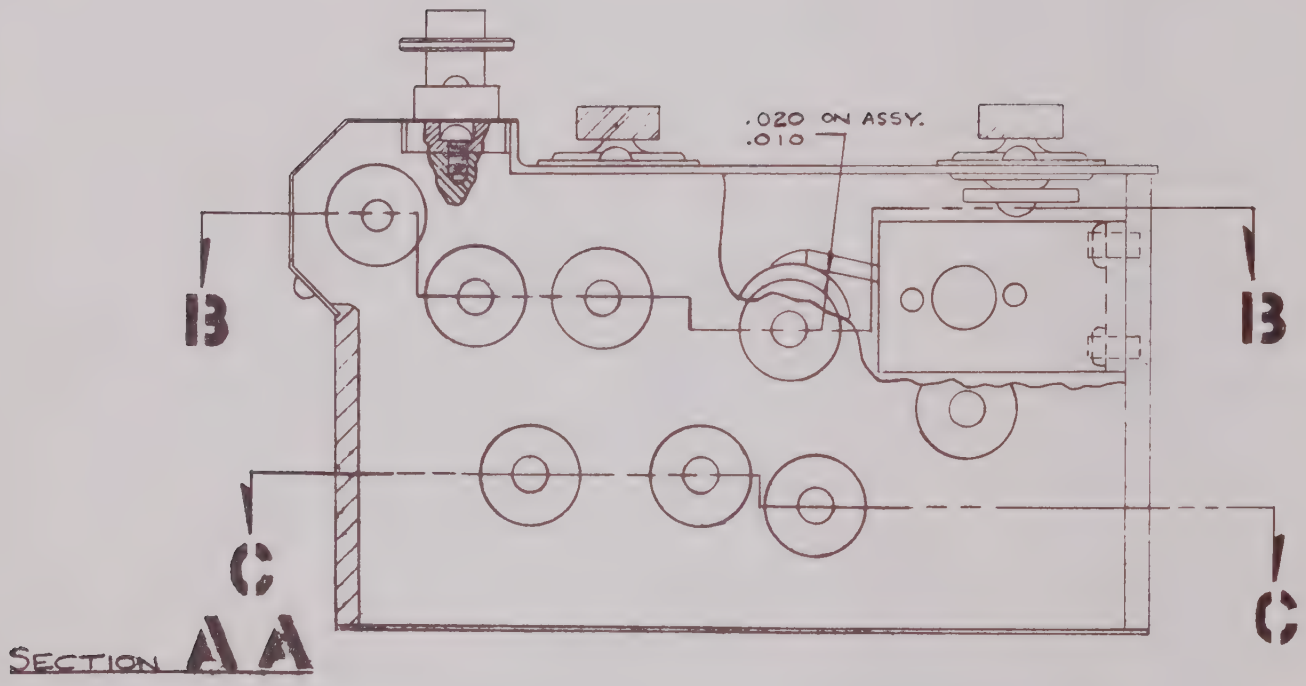
FIG. 6:18

ITEM	DESCRIPTION	PART NO.	NO. REQ'D.
71	SOLENOID, ROTARY	43668	1
76	BRAKE BAND ASSEMBLY	43662	1
78	PLATE, BRAKE	43636	1
85	COUPLING, TRANS. INPUT	43669	1
88	RING, RETAINING	39832-125	1
89	PIN, ANCHOR	43654	1





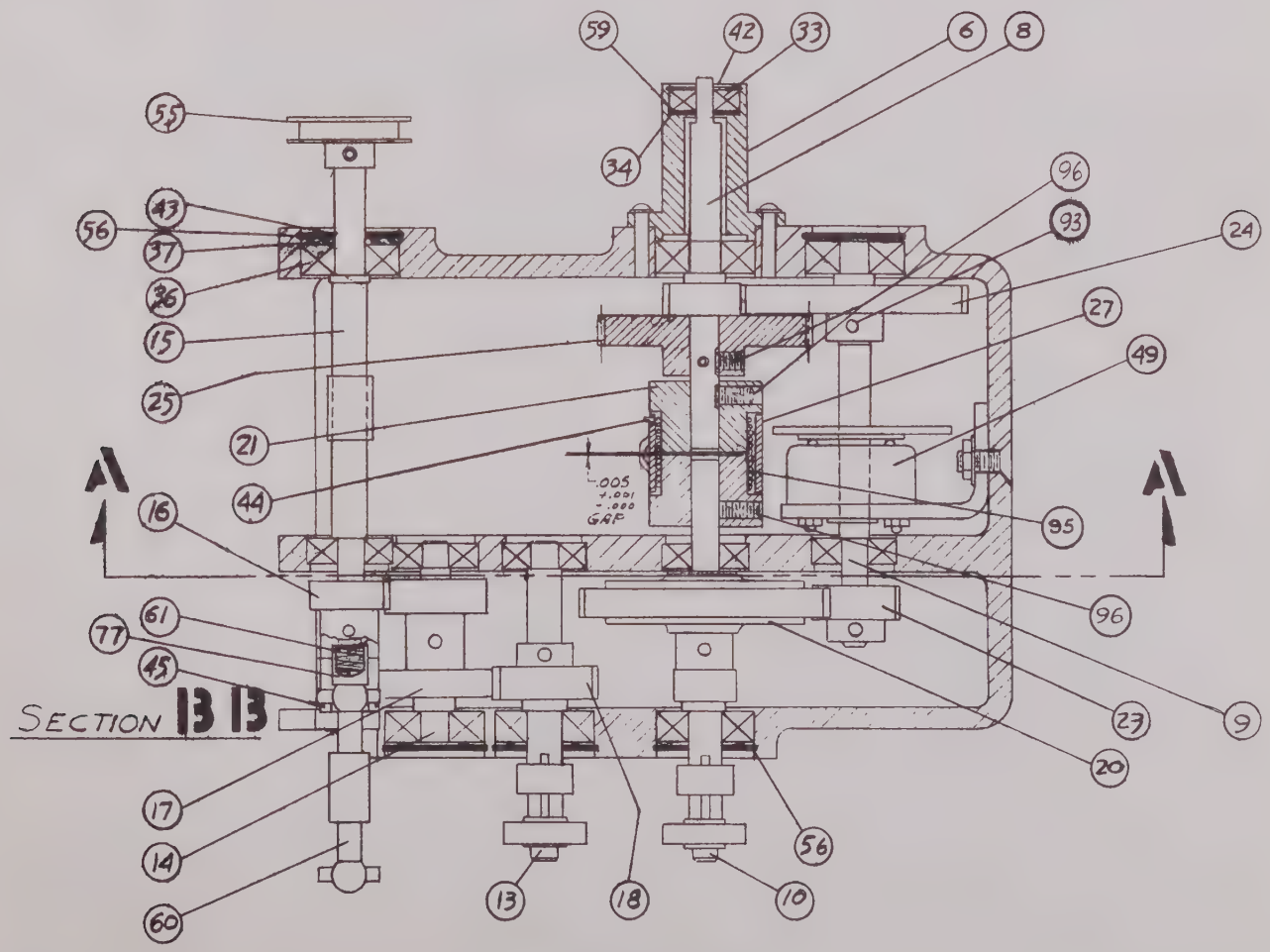
BRAKE MECHANISM ON THIS VIEW ONLY



TRANSMISSION ASSEMBLY

FIG. 6:20

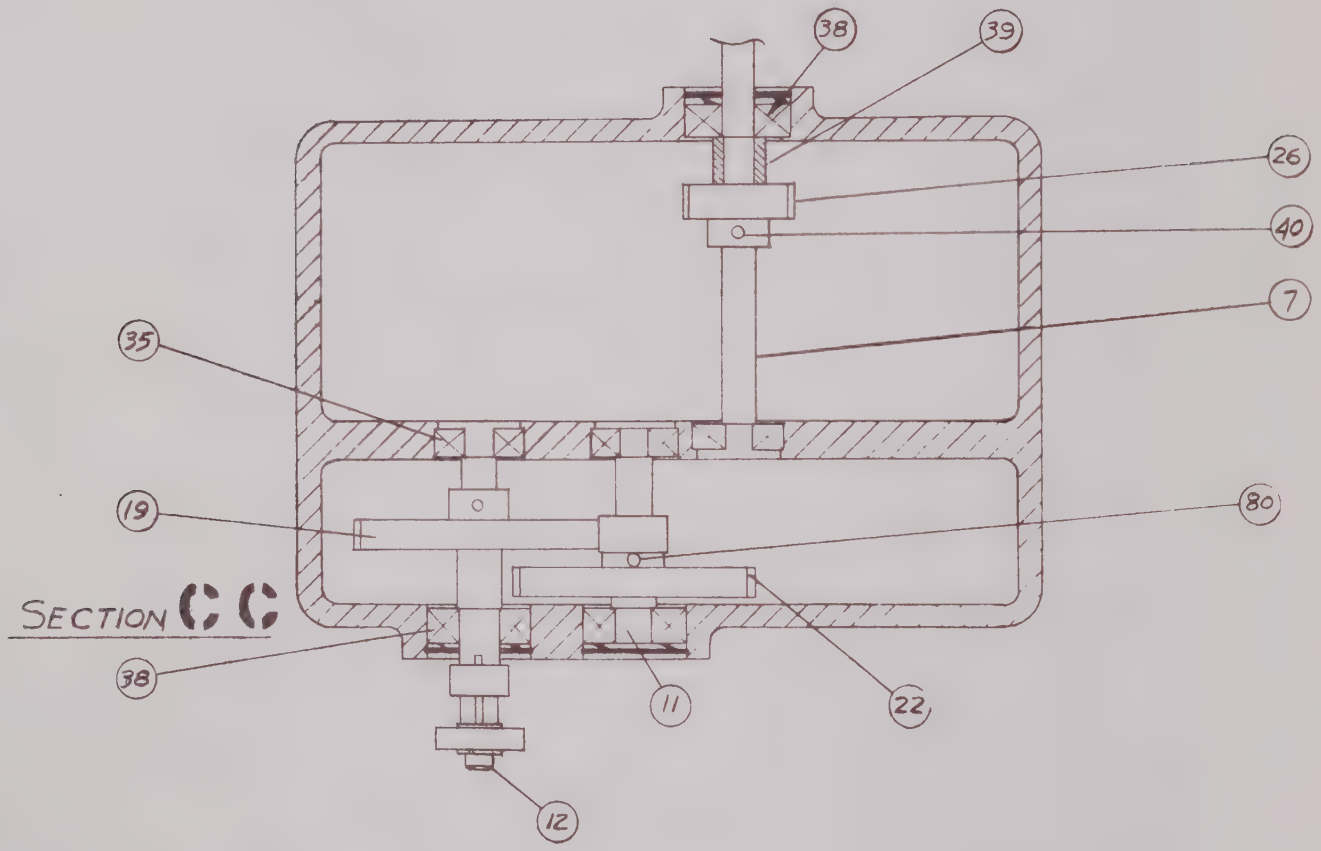
ITEM	DESCRIPTION	PART NO.	NO. REQ'D.
6	BEARING, HOUSING	29672	1
8	SHAFT, B	37162	1
9	SHAFT, C	29675	1
10	SHAFT, D	37163	1
13	SHAFT, G	29679	1
14	SHAFT, H	29680	1
15	SHAFT, WORM	29681	1
17	GEAR & PINION ASSEMBLY	47115	1
18	GEAR, HELICAL	47113	1
20	OVERRIDING CLUTCH ASSEMBLY	33623	1
21	DRUM, CLUTCH	37043	2
23	GEAR, HELICAL 31-48T	29684	1
24	GEAR & HUB ASSEMBLY, 48-98T	36583	1
25	GEAR, 40-69T	154220	1
27	SLEEVE SPRING	37044	1
33	BEARING	29780	1
34	SPRING, BEARING	29801	1
36	BEARING	29782	5
37	SPRING, BEARING	29800	8
43	RING, RETAINING (SPIROLOX)	29602	8
44	SPRING, CLUTCH	154270	1
45	RING, RETAINING (SPIROLOX)	25607	1
49	SOLENOID ASSEMBLY	37049	1
55	PULLEY ASSEMBLY	30097	1
56	WASHER, RETAINER	33325-10	10
59	SHIM	41389	As Req'd.
60	SHAFT ASSEMBLY	29978	1
61	SPRING	30020	1
77	SLEEVE, CENTERING	33375	1
93	ROLL PIN, 3/32 DIA. X 11/16 LG.	22628-61	1
95	MOLYKOTE, TYPE M-77	17484-32	As Req'd.
96	LOCKTITE SEALANT, TYPE "C"	17484-98	As Req'd.



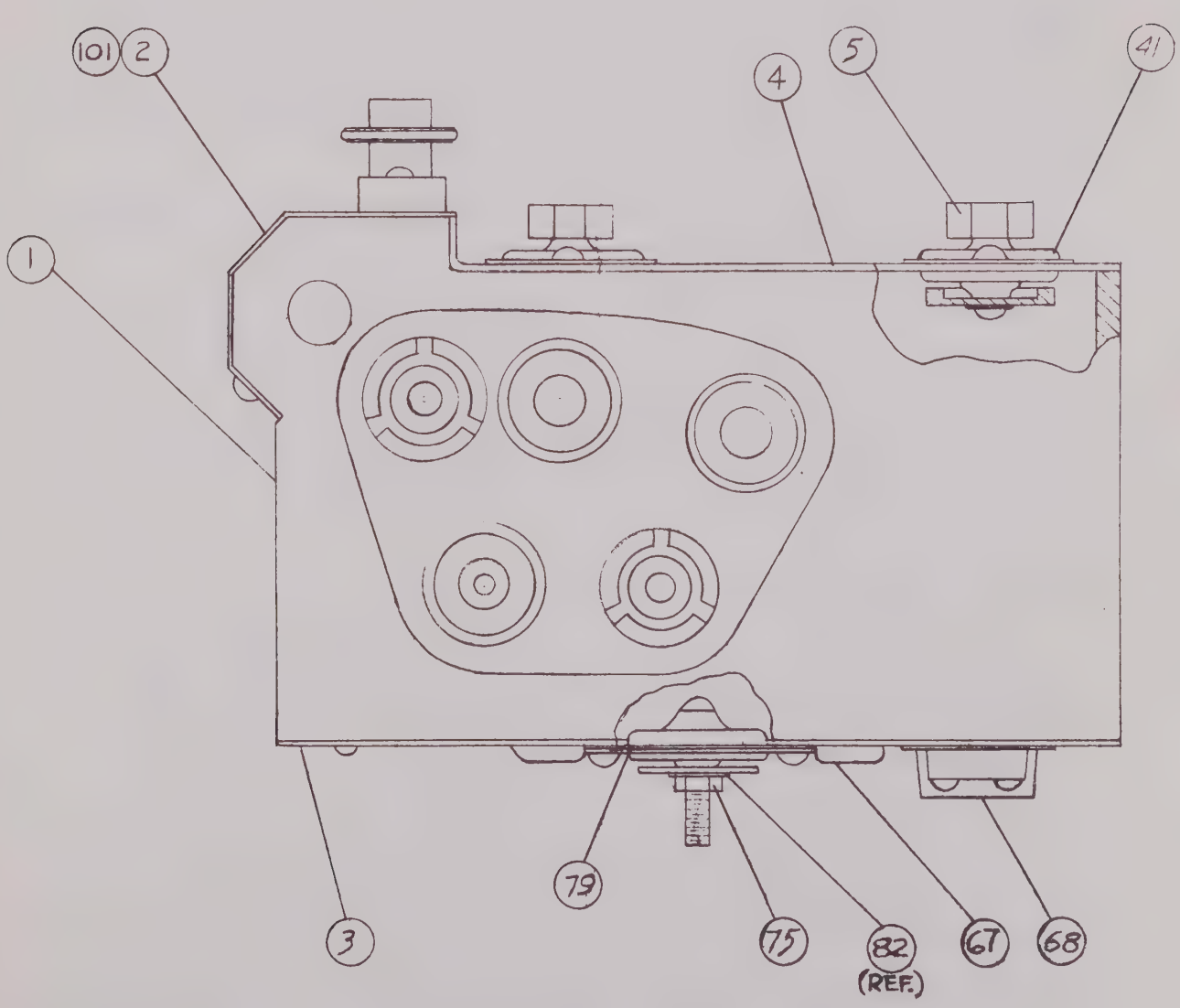
TRANSMISSION ASSEMBLY

FIG. 6:21

ITEM	DESCRIPTION	PART NO.	NO. REQ'D.	
7	SHAFT, A	37075	1	
11	SHAFT, E	29677	1	
12	SHAFT, F	20678	1	
19	GEAR & HUB ASSEMBLY	29688	1	- $23.00
22	GEAR & PINION ASSEMBLY	29687	1	- 41.00
26	GEAR, 40-69T	29682	1	
35	BEARING	20781	8	
38	BEARING	20783	4	
39	SPACER	37073	1	
40	ROLL PIN, 3/32 DIA. X 1/2 LG.	22628-31	7	
80	ROLL PIN, 3/32 DIA. X 7/16 LG.	22628-21	1	



ITEM	DESCRIPTION	PART NO.	NO. REQ'D.
1	HOUSING, TRANSMISSION	51189	1
2	COVER, TRANSMISSION	29669	1
3	PLATE, TRANSMISSION	52020	1
4	PLATE, SHOCK MOUNT	52021	1
5	BAR, TRANSMISSION	52022	2
41	SHOCK MOUNT	29817	5
67	GROMMET	6887-39	2
68	TERMINAL STRIP	42405-8	1
75	NUT, HEX, #8-32	7074-280	3
79	SPACER, SHOCK MOUNT	34323	1
82	LOCKWASHER, INT. #8	7058-52	7
101	COVER, TRANSMISSION	51251	1



TRANSMISSION ASSEMBLY

FIG. 6:23

C. MAINTENANCE GUIDE

This Maintenance Guide outlines the steps of a periodic maintenance check. The guide may be reproduced for convenience of filing instrument status reference. Reprints of this guide are available from your local Consolidated Electrodynamics Corporation District Office, or from the Pasadena factory.

1. Remove all front access panels and bottom of oscillograph. Remove air filter and record number counter housing cover (left side of oscillograph). The paper drive motor should be free in its mount with no obstructions to hamper the action of the shock mounting. Examine all shockmounts for sag or any indications of excessive wear.

2. Try each speed change gear on each of the three transmission shafts and inspect for signs of damage.

3. The automatic record length control should turn rather stiffly but not bind. Set speed change gears for 1 and 10 inches per second. Set the control to a record length of 10 inches. Operate the oscillograph in automatic, and check that the running time is approximately correct for a 10-inch record length. Operate the oscillograph in automatic two more times at different settings and see that the running times correspond to the initial running time. Any discrepancy indicates a malfunction of the automatic record length system.

4. Set the automatic record length control to zero. The oscillograph should not operate in AUTOMATIC.

5. Gradually increase the automatic record length setting while trying to operate the oscillograph in AUTOMATIC. The oscillograph should start to operate short records by the time the indicator reaches 5.

6. Set the record length control at some convenient value at approximately mid-scale. Operate the oscillograph in AUTOMATIC and time the running interval to determine whether the calibration is correct. If the calibration is off, loosen the set screws in the record length knob and reset the knob to the correct value. Operate the oscillograph in AUTOMATIC at this setting several times to determine that the running time is consistent. Any variation in running times is cause for rejection and repair. Repeat for low and high voltage limits.

Low voltage - 105 a-c volts
High voltage - 125 a-c volts

7. Set the record length control at maximum. Operate the oscillograph in AUTOMATIC several times and check the running times for accuracy and repeatability. Automatic record length running times should agree with the selected value ±15%.

8. Using the viewing screen, check that the dynamic and static reference traces are properly centered on the collimating lens. All adjustments should be smooth but positive.

9. Operate the polygon scanning drive in both high and low gears. In low gear the polygon operation should be smooth and reasonably quiet throughout its range. In high gear the polygon will be stalled in the lower portion of the speed control range. However, it should operate smoothly and without excessive noise throughout the rest of its range.

10. The timing line should be sharply in focus and lie along its correct horizontal line (within 0.010). With the timing line lever to the left, the timing line should completely cross the record aperture; with lever to the right, there should be one inch of line at each edge.

11. 1/2 inch of timing line should be visible at the center of the scanning screen. Focus should be sharp.

12. Check that all lenses and mirrors are free of dirt, paint, dust, and lint. Check carefully that the lens and mirror mounting screws are not loose. Clean mirrors and lenses with soft camel-hair brush. Do not use Kimwipe. All mirrors are surface-coated type. Use damp lens tissue lightly to remove finger-prints or heavy dirt. (Alcohol-wetted cotton preferred.)

13. Hold a piece of white paper in front of the magnet block and check that all galvanometer slots and reference traces are properly illuminated by the galvanometer lamps. Press the reserve lamp and recheck.

14. Operate the oscillograph in MANUAL without a magazine installed. The NO RECORD section of the indicator should be illuminated as well as the RECORDING section. Simulate a timing lamp burnout by removing the timing lamp. The NO TIMING LAMP section of the indicator panel should be illuminated.

15. Using a ground glass or the frosted edge of a galvo card in front of the lens tube, check that the photographed counter is sharp and synchronized with the panel counter. Reset the counters and see that both units zero correctly and that the reset mechanism locks properly.

16. With the oscillograph operating in MANUAL, observe the trace identifier operation. The pins should be straight in the belt so that they do not strike any part of the oscillograph during their excursion.

17. With power applied to the oscillograph, check that the paper drive motor starts immediately and the galvanometer and timing lamps change brilliance when the motor starts and stops.

18. With the paper drive motor running, the galvanometer and timing lamp voltages should be adjustable.

19. Record the actual input voltage to the oscillograph and the reading of the oscillograph meter. The oscillograph meter should indicate the actual voltage ±10%.

20. Vary the left and right galvanometer lamp controls, and observe that the lamps change brilliance. Depress the reserve lamp test button and repeat for the reserve lamps. Set the main galvanometer lamps on 10 volts and depress the reserve lamp test button. The meter should still read 10 volts. If a discrepancy is noted, adjust R-138 or R-145 to obtain the proper reading.

Set the galvanometer lamps at 10 volts and the jump speed switch in LOW position. When the jump switch is moved to HIGH position, the lamp voltages should increase to 14 or 15 volts. If discrepancies are noted, adjust R-146 and R-147 to obtain the proper values.

Vary the timing lamp control and observe that the timing lamp changes brilliance properly. Set the jump speed switch on LOW position and the timing lamp on 10 volts. When the jump speed switch is moved to HIGH position, the lamp voltage should increase to 13 volts. Adjust R-149 to obtain the proper reading.

21. Set the input to the oscillograph at low voltage (105 volts). Turn the oscillograph power on and off five times, noting that the timing motor starts readily each time.

22. Insert the bulb of an immersion type thermometer approximately in the center of the magnet block gap. Insert a dummy galvanometer on either side of the thermometer to serve as a means of support and to cut down air circulation through the block. With the power on, the block temperature should rise to 100 ±1°F and stabilize. Check that the thermostat properly cycles the block heater relay to maintain block temperature. The cabinet thermostat should be set to cycle at 92°. Note its location in operations manual.

23. Inspect the viewing screen for cracks, blemishes, and alignment of the grid. The viewing screen cover should fit well and operate smoothly on its hinges.

24. Operate the power, jump speed, and record switches and inspect for proper operation. Occasionally the power and record switches might be mounted so that the slightest jarring of the oscillograph will cause them to return to the off position. The switches should be securely mounted and positive in action.

25. Depress the WARNING LAMPS test button. All of the indicator panel lights and the block heater pilot light, except the RECORDING lamp, should come on.

With the RESERVE LAMPS test button depressed, vary the pressure on it from side to side and up and down. There should be no erratic operation of the reserve or main lamps. Repeat the "wiggle" test on the WARNING LAMPS test button.

26. Depress the Thumb-trols and check carefully that as the Thumb-trol moves down it activates both microswitches.

With the Thumb-trol depressed, rotate it and check that the operation is smooth, with no noticeable binding.

With the Thumb-trol in a relaxed position, see that it locks sufficiently tight to eliminate any chance of accidental change in setting.

27. Inspect the indicator windows. Mounting should be secure and straight. Check for light traps between windows.

28. Inspect the magazine drive shaft for spring loading and proper alignment. The shaft should protrude straight from the oscillograph. Deflect the shaft from its normal position. When released, it should return to its proper position. Depress the shaft axially and feel for any possible binding in the spring loading.

29. Inspect the galvanometer lamp assemblies for ease of insertion and removal of lamps and for proper electrical contact with lamps.

30. Simulate galvanometer lamp burnouts by removing the main lamps. Check that the reserve lamps come on automatically upon removal of the main lamps.

31. Inspect the timing lamp assembly for secure installation, ease of installing and removing lamp, and proper electrical contact with it.

32. Index the timing line disc from 0.01-second timing lines to 0.1-second timing lines. Indexing movement should be smooth with no apparent binding.

33. Depress the WARNING LAMPS test button. The NO RECORD and NO TIMING LAMP indicators should come on and the BLOCK HEATERS pilot light should come on at full brilliance. While the button is depressed, wiggle it and see that no erratic operation results. Set R-123 in accordance with the schematic diagram.

34. With the RECORD switch still in MANUAL position, flip the JUMP SPEED switch from LOW to HIGH. The output shaft speed should increase immediately and the galvanometer and timing lamp intensities should increase. Flip the switch back to the LOW position. The output shaft speed should immediately decrease as should galvanometer and timing lamp intensities. Output shaft rpm should be 210 at 10 inch/second gearing. At JUMP SPEED range of 100 inches/second, output shaft rpm should be 2100.

High Speed _____ rpm

Low Speed _____ rpm

35. Place the RECORD NUMBERING switch in AUTOMATIC position. Flip the RECORD switch to MANUAL and back. Each time the switch is returned to the OFF position, the data flash should operate. Operate the oscillograph in AUTOMATIC. At the end of the record run, the data flash should operate.

Place the RECORD NUMBERING switch in EXTERNAL position. Operate the oscillograph in MANUAL as before. When the RECORD switch is returned to the OFF position, the data flash should not operate. Return the RECORD NUMBERING switch to the AUTOMATIC position.

36. All bushings in the oscillograph and magazine should be oiled every 300 hours of operation. Use SAE 10 engine oil containing no detergent.

37. The brushes in the drive motor (2 sets) should be inspected every 500 hours or less. When brushes have worn down to 3/8" in length they should be replaced, regardless of their length of time in use. The blower motor has no brushes.

38. Reassemble the oscillograph.

D. MAGAZINE SERVICING, CATALOG NO. 5-006A, 5-032

The following describes the standard recommended periodic servicing of the 5-119P4 Oscillograph Magazine to assure continuous trouble-free operation. It is further recommended that this particular service be set up on a quarterly or bi-annual basis, depending on how much use the magazine is subjected to.

Material required: Test roll of paper, 20 feet each of Lino-Writ 1 and 4

Special tools needed: Two scales - 0-15 lbs., 0-64 ounces, G. R. Strobotac, 1 pair TL #28600-B9 spool clamps, Clarkston Microscope Wrench (Fig. 6:28). (TL#28600-B9 spool clamps are available on order from the factory.)

General: A 5-119P4 Oscillograph and the magazine to be checked will be necessary.

(EDITOR'S NOTE: Numbers in the body of this procedure which appear in parenthesis, i. e., (42) (157), etc., are for part location reference on drawings.)

Procedure:

1. Preliminary Checks and Adjustments

a. Insert a screwdriver in the shutter guide (74) and open the shutter. Check that the recording and data flash shutters open and close freely without binding. Open and close slowly several times.

NOTE: Perform this operation with magazine in vertical position.

b. Remove lid, place empty spools in the magazine, and check clearance between spool flange assembly (156) and both feed and takeup clash gears (42). At the same time, check for freedom of movement of the clash gears and that the gears mesh with the spool gears.

c. With spools in magazine, place lid on top without turning down lid mounting screws. Note whether all four spool retainers (115) (120) are making good contact with the ends of the spools.

d. Check freedom of movement and end play of not more than .004" on metering roll (50) and not more than .006" on feedbrake assembly (35) and paper spools.

2. Takeup Clutch Adjustment (Fig. 6:25)

a. Place an empty spool in the feed-roll position of the magazine. Mount an empty roll, with a cord fastened to it and to a pound scale (0-15 lbs.), in the takeup roll position - clamp spools with clamping fixtures (TL #28600-B9 Spool Clamp) or hold in place by hand. Lack of clamps necessitates the use of two people for this check.

b. Set 5-119P4 Oscillograph for speed of 10 - 100 ips and mount the magazine.

c. Using a cord fastened to a pound scale (0-15 lbs.), with the other end around the takeup spool, determine the force of pull at high speed operation (100" per sec). Adjust takeup clutch (134) for 5 lbs. - 0 +12 oz. pull. Should additional tension be necessary, see note in Fig. 6:25.

3. Delivery Clutch Adjustment (Fig. 6:23, 6:24, and 6:25)

a. Place a cord around an empty spool in the feed roll position and fasten the right spool end down with the fixture. (Hold the other end by hand.) Using a 0 - 64 oz. scale, check tension of brake clutch (59). The tension should be 28 - 32 ozs. Make necessary adjustments on the drag adjusting pin (105).

b. Place a full test roll in the feed roll position and fasten the right spool end down with the fixture. (Hold other end with hand.) With a cord attached to both a 0-64-oz. scale and around the end of the test roll, the tension required to turn the feed roll should be 58 - 64 oz. of pull. With the full roll, check the footage indicator dial (±10%). Also, observe that the loop on the limiter spring (41) about the drag adjusting pin (105) has enough clearance to be free from producing tension on the clutch cord (121). Remove roll.

4. Adjustment of Mechanical Paper Length Indicator (Fig. 6:24)

a. If necessary, adjust the mechanical indicator of the magazine to read zero paper (empty) by adjusting the length of the footage indicator cable (114).

Press the paper drag arm (152) in the magazine until the magazine indicator reads 1/2. Adjust the footage calibrate potentiometer on the Remote Control so that the footage indicator reads 1/2.

b. Release the paper drag arm and note that the paper length meter reads zero or empty.

> NOTE: To adjust, remove the cover over the gear and clutch compartment. Rotate the potentiometer with a screwdriver, loosen Allen screws (bottom one first) and make necessary adjustment by rotating the footage dial to correspond with the reading on the footage indicator. Make certain the cable does not slip off the pulley on the side of the footage dial when performing this operation.

c. Press the paper drag arm in until the magazine indicator reads full. The footage indicator on the Remote Control should read full ±10%.

d. Release the paper drag arm and again note that the paper length meter reads zero. If not, repeat step b. above.

5. Commutator Brush Adjustment (Fig. 6:27)

Remove magazine side cover casting and inspect brushes on commutator (131) for proper seating. Also, check brush tension (40 - 60 grams) on surface of commutator.

6. Records (Clutch Adjustment Verification)

a. Load the magazine with a full, dummy roll of 12-inch paper, using the special clamps to permit the magazine to be operated with the cover removed. Run the dummy roll of paper through, observing proper operation. Reload the magazine and mark one spot on the metering roll (50) with a piece of chalk. Set up the G. R. Strobotac, carefully calibrated, so that the metering roll may be strobed while running the dummy roll through.

b. Operate the oscillograph in MANUAL and run the first half of the roll through in "bursts", alternating the JUMP SPEED switch from HIGH to LOW position in one second intervals. Watch carefully for any indication of transmission or clutch trouble which will usually be evidenced by excessive vibration and noise.

c. Run the balance of the roll through at high speed, low voltage (105 volts) strobing the metering roll carefully to obtain a reading on minimum speed at the end of the roll. Convert the end of roll metering roll rpm to inches per second (100 inches per second equals 1470 rpm). The average of the start-of-roll and end-of-roll speeds should be 100 inches per second ±10%.

d. Load the 5-006 Magazine (or 5-006A, 5-032) with approximately 20 feet of 12-inch Lino Writ #1 or equivalent recording paper rolled onto an empty roll to simulate end-of-roll conditions. Install the proper change gears for 10 - 100 inches per second and set the JUMP SPEED switch in the HIGH position.

e. Index the timing line system to present .01-second lines the full width of the paper. With the JUMP SPEED switch in the HIGH position, adjust timing lamp voltage to approximately 16 volts. (With FLASH TIMING, disregard the voltage setting in this section.) Then place the JUMP SPEED switch in the LOW position. Place the RECORD switch in the MANUAL position. After 1 second, place the JUMP SPEED switch in the HIGH position for a period of 1 1/2 seconds, then return it to the LOW position for the balance of the record run.

(1) Process the record and evaluate it as follows: Measure the high-speed portion of the record to see if it reached 100 inches per second ±10% within 0.35 seconds. Record the value of the stabilized speed for reference.

(2) The jump up or down in speed should not exceed 0.35 seconds stabilization time. Check that timing lines do not pile up on the jump down in speed.

7. Timing Line Records (Proper Transport Verification)

a. With the timing lines set for full width, 0.1-second presentation, the change gears set for 0.1 or 1.0 inches per second paper speed and the JUMP SPEED switch in the LOW position, set the timing lamp voltage to 9.5 volts and the galvanometer lamp voltage to 5 volts or below (in order to lower the contrast on any galvo traces present).

b. Attach the magazine being tested (loaded with 12-inch Lino Writ #1 paper or equivalent) to the oscillograph. Set the automatic record length control to 20 inches. Place the RECORD switch in the AUTOMATIC position momentarily to start the record run. After 10 seconds operation, place the JUMP SPEED switch in the HIGH position for 3 seconds and return it to LOW position. Allow the record run to finish, and process and dry the record.

(1) Examine the record for smooth paper transport. If any variations appear, measure the distance between timing lines with the Clarkston microscope. The measurement should be the nominal 0.10" ±10%.

(2) Examine the jump speed portion of the record. Note that the increase and decrease in record speed is accomplished smoothly.

8. Handle Check (Fig. 6:26)

a. Handle inspection is made by placing the magazine on the oscillograph. Bring handle part way down toward lock-in position. Note the lateral or centering position and spacing of the magazine arm castings with respect to the oscillograph magazine release springs.

b. If the arm castings are off center, the fault can be corrected by loosening the 10-24 capscrews holding the handle-mounting casting in place, positioning the casting, and re-tightening the capscrews. These capscrews are located inside the magazine in the center above the delivery spool.

NOTE: The customer is not expected to have the following aligning jig. This unit will be made available for this check during a normal service visit of your Consolidated Electrodynamics Field Service Engineer if the Field Engineer is previously notified of your desire to use the jig.

c. With the master magazine aligning jig, align the rack and pinion assembly on the front casting of the oscillograph. Adjustment is made by inserting pin through the aligning hole on the fixture. The pin, which has a hole in it, should fit snugly down over the shutter pin.

Vertical adjustment is made by loosening the jam nut at the base of the rack and pinion and raising or lowering the 10-32 stop screw. After adjustment secure into place by resetting the jam nut.

REFERENCE PARTS LIST

For Figs. 6:24, 6:25, 6:26, 6:27, and 6:28

ITEM	DESCRIPTION	PART NO.	NO. REQ'D.
5	Collar - Boston	19977	1
6	Tube (Ref. only)	31557	
16	Bearing - Flanged	31991	5
21	Belt - Drive	37617	1
23	Retaining Ring	31388	1
24	Key - Roller Drive	30297	1
25	Pulley	29892	1
26	Gear - Helical, 32 Teeth	29836	1
27	Gear - Helical, 26 Teeth	29837	1
29	Welch Plug	19642-5	3
35	Drag - Shaft Assembly	37342	1
39	Roll Pin .078 Dia. x 5/8	22628-50	1
42	Gear - Clash, 46 Teeth	29838	2
44	Ring - Retaining	21891-7	3
45	Bearing - Flanged	31353	1
48	Connector	31085	1
50	Roller - Metering	29969	1
51	Bearing - Ball	29783	1
52	Spacer - Roller Drive	30298	1
58	Cord Assembly - 12 Inch	30649-1	1
59	Shaft - Drag Clutch	30087	1
63	Retainer - Bearing	33899	1
72	Spring - Shutter Lock	30804	1
73	Shutter Actuator Assembly	30245	1
74	*Shutter Assembly	30250	1
77	Guide - Paper	30092	1
101	Dowel Pin .125 Dia. x 3/8	7211-10	2
102	Pin - Mag. Stop	30533	2
103	Shim - Mag. Stop	30532	As Req'd.
105	Pin - Drag Adjusting	30841	1
113	Assembly - Nut Bracket	30215	1
114	Assembly - Footage Indicator Cable	29922	1
115	Retainer - Spool	30117-1	2
116	Lid Mtg. Screw Assembly	30317	2
117	Retaining Ring	24199-7	2
118	Spring - Drag Tension	30803	1
119	Commutator Brush Assembly	31176	1
120	Retainer - Spool	30117-2	2
121	Cord Assembly - 3 Inch	30649-2	1
124	Limiter - Spring	32560	1
125	Molykote Type M-77	Ref	1
131	Commutator, Paper Jam, Sub-Assembly	36028	1
132	Input Shaft Assembly	36037	1
134	Takeup Clutch Sub-Assembly	36081	1
135	Footage Supply Drum Sub-Assembly	36086	1
151	Impregnated Felt Faces	30044	2
152	Arm - Paper Drag	30091	1

ITEM	DESCRIPTION	PART NO.	NO. REQ'D.
154	Shaft Assembly	30596	2
154	Shaft Assembly (5-032 Magazine)	49228	2
155	Spool Assembly	30597	2
155	Spool Assembly (5-032 Magazine)	49225	2
156	Flange Assembly, Clip End, Round	30595	2
156	Flange Assembly, Clip End, Hexagonal	33168	2
156	Flange Assembly, Clip End, Insulated (5-032)	49226	2
157	Drag Spring	33736	1
158	** Pad	33735	1
159	*** Drag Spring Assembly	33734	1
160	Guide - Spool Shaft	30127	2
161	Magazine Handle & Lock Assembly	36076	1
162	Clutch Assembly, Takeup	36081	1

* Coat shutter guide with Molykote Type M-77

** Use E. C. 870 Minnesota Mining and Manufacturing Co. Cement

*** See Items 49, 50.

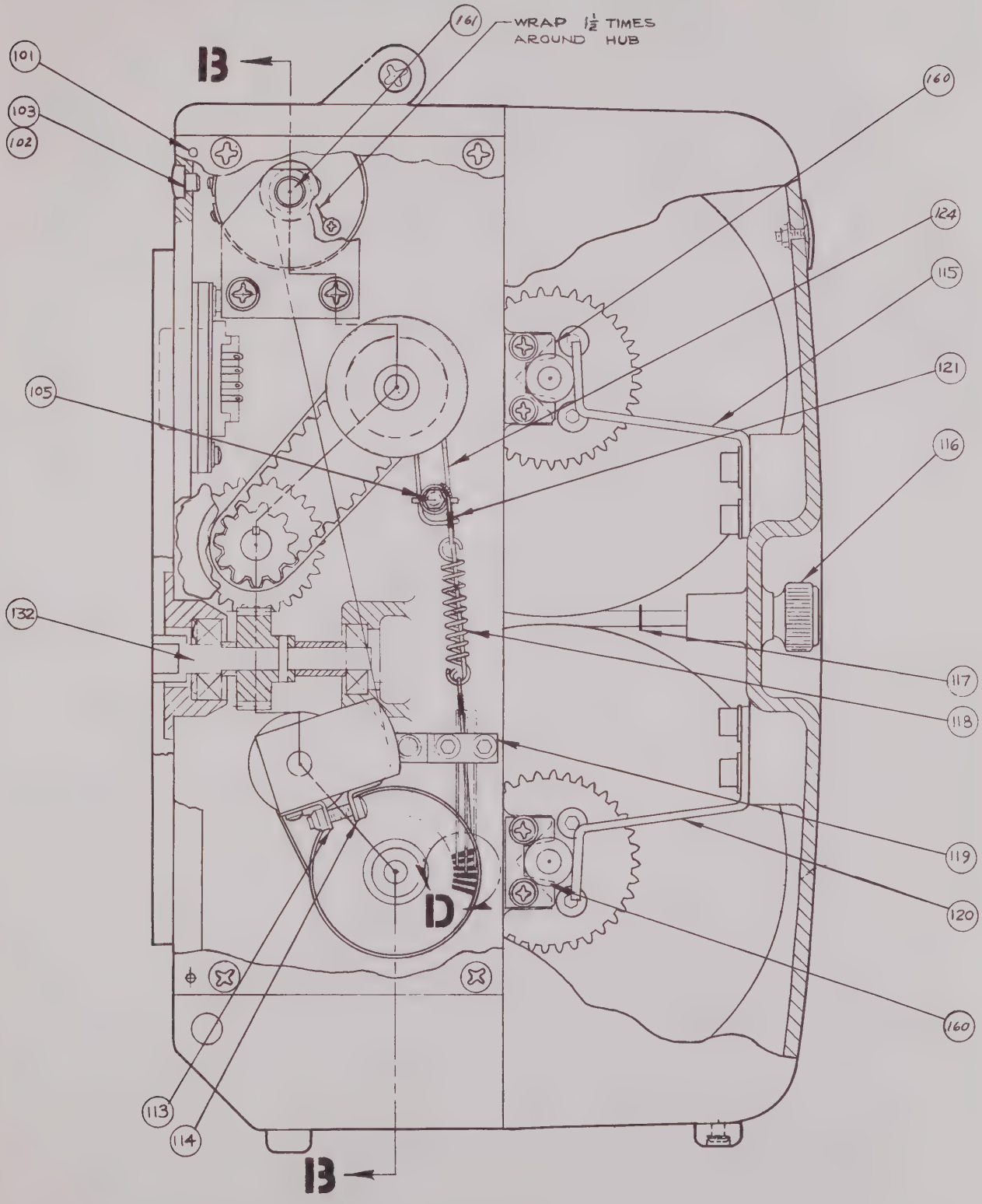
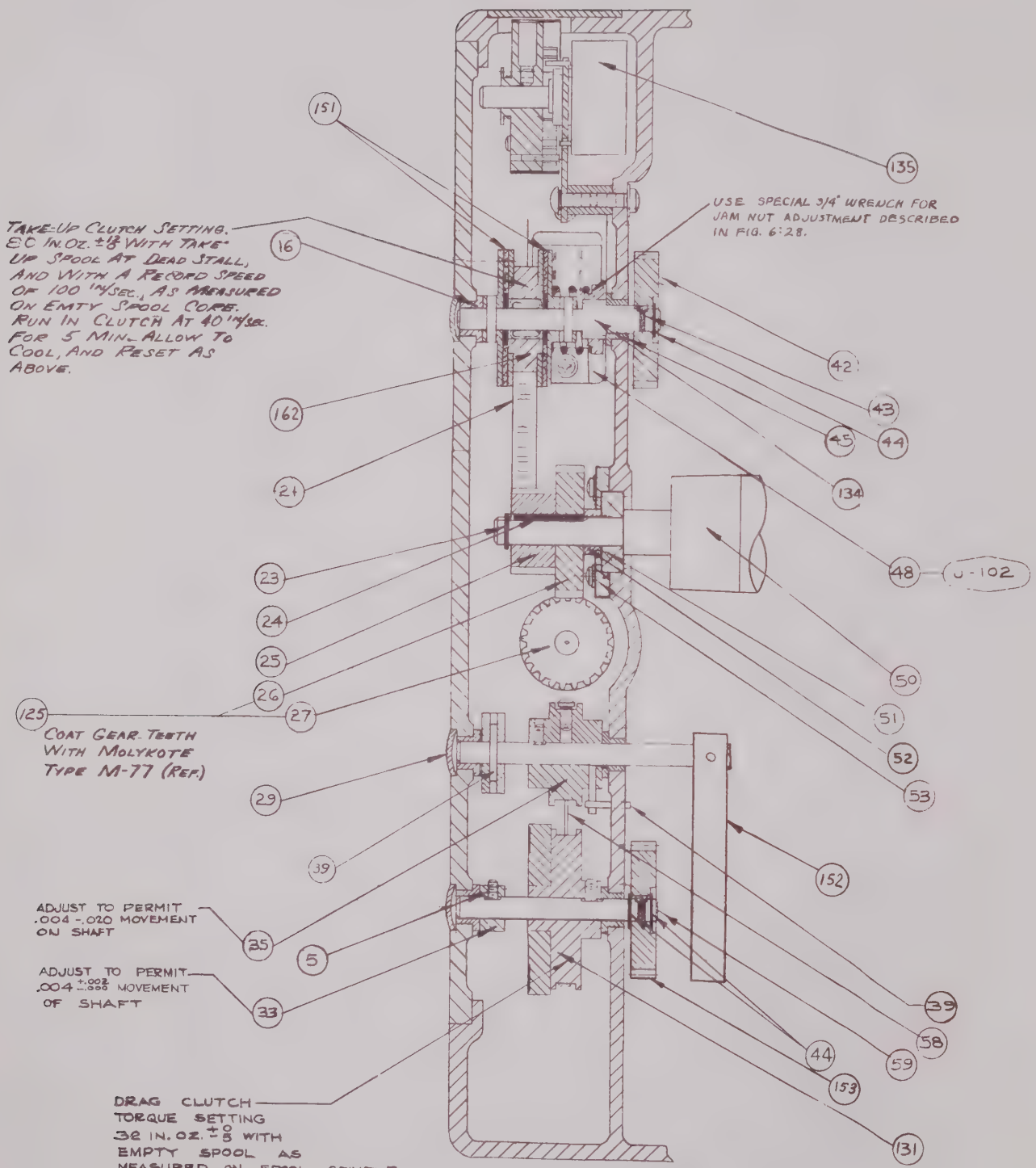


FIG. 6:24
5-006A MAGAZINE, LEFT SIDE

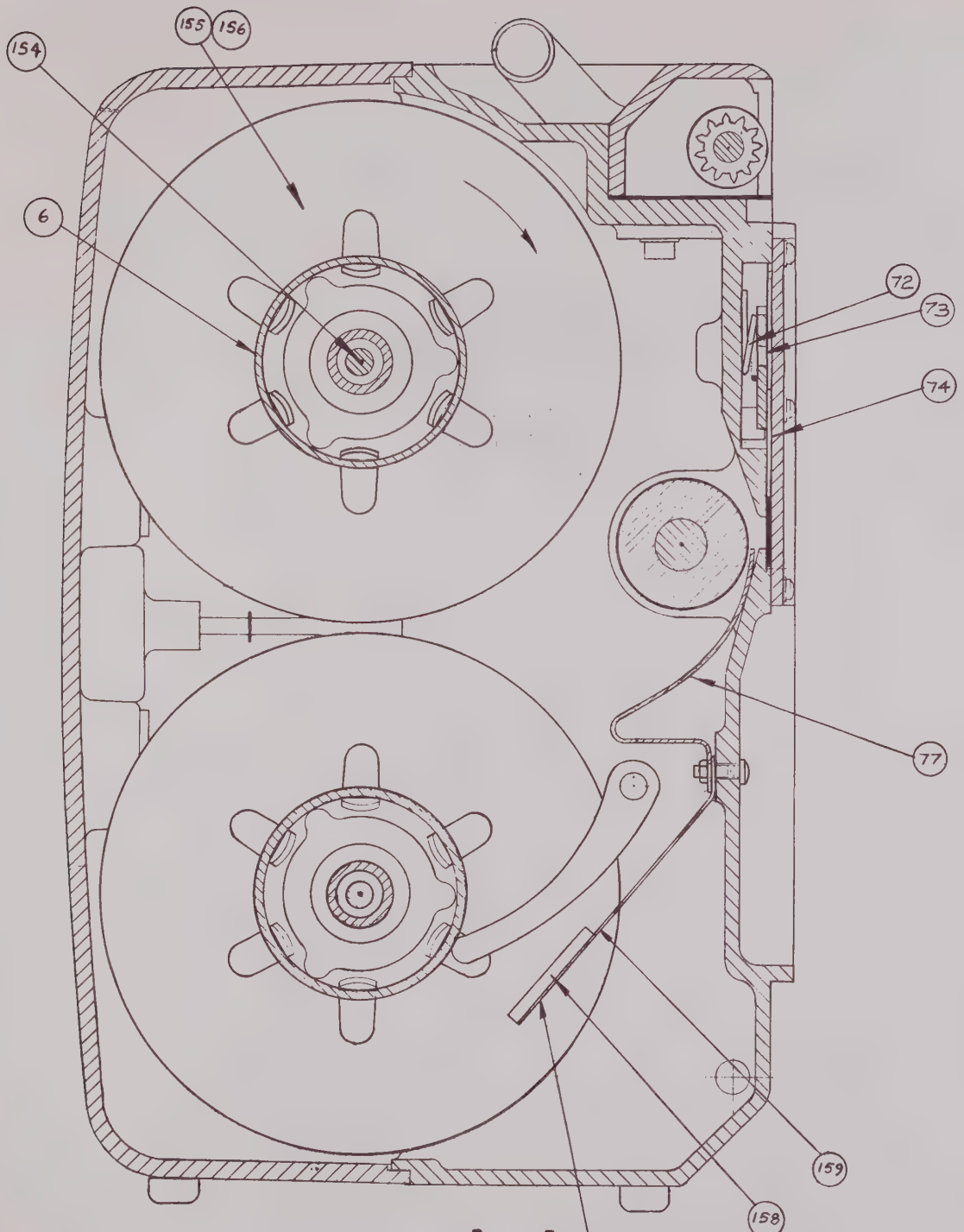
5-119P4
6-59 2061



SECTION **13-13**

FIG. 6:25
5-006A MAGAZINE, GEAR DRIVE

5-119P4
6-59 2061



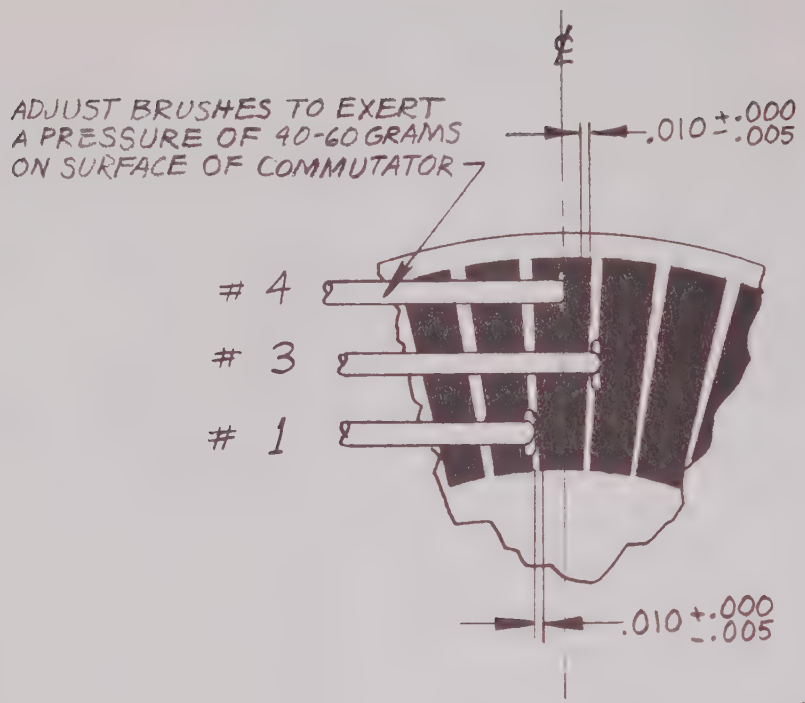
SECTION A-A

BEND SPRING TO PROVIDE A DRAG OF 56 TO 64 OZ. AS MEASURED ON (PAPER) SPOOL RADIUS OF 2 3/8 (ADJUST AFTER DRAG CLUTCH SETTING)

FIG. 6:26

5-006A MAGAZINE, RIGHT SIDE

R-28600



SECTION "D"

FIG. 6:27

5006A MAGAZINE, BRUSH ADJUSTMENT

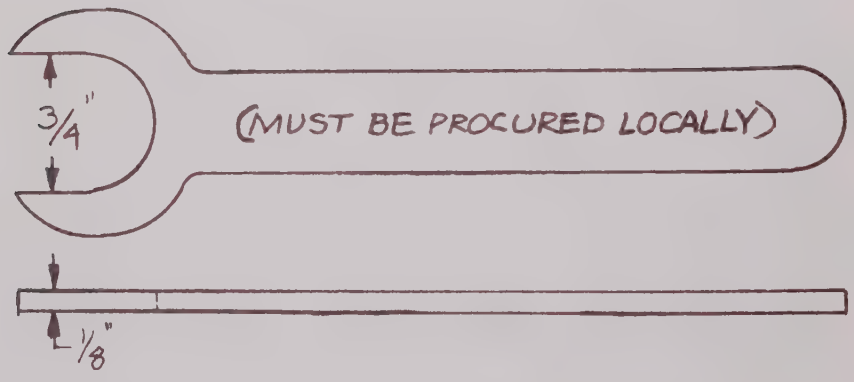


FIG. 6:28

SPECIAL JAM NUT WRENCH

REF. DWG. R-28600

PART VII

CABLING

Fig. 7:01 (next page) gives both a description and schematic diagram of all cables directly associated with the operation of the 5-119P4 Recording Oscillograph. Catalog numbers are furnished for those who wish to order cables completely fabricated by CEC. Manufacturer's numbers are also furnished for those who wish to fabricate their own cables.

The standard lengths listed are those which have been found most convenient for the majority of installations. If special lengths are needed, please contact your local sales office, indicating the cable Cat. No. and the length desired.

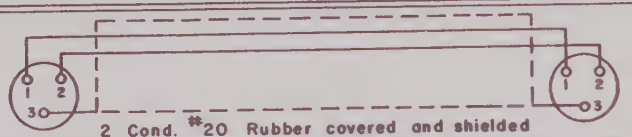
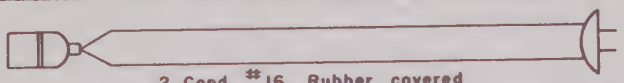
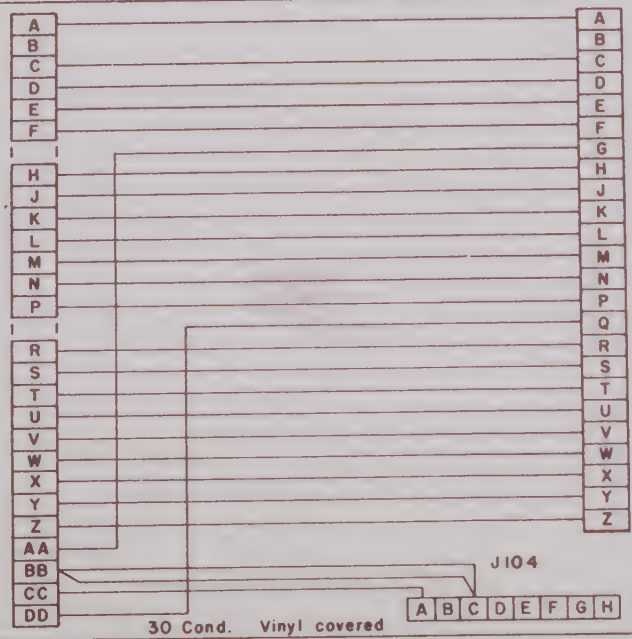
FROM	TO	CABLE SCHEMATIC	CAT. NO.	L'GTH	CONNECTORS		
					CEC. CAT. NO.	MFG.	MFR'S. NO.
Signal Source	5-119 Galvanometer Input Receptacle		49597	10 ft.	(A) 8792 (B) 8792	Cannon Cannon	XL-3-11 XL-3-11
5-119 P 4 Oscillograph	AC Line		49636	10 ft.	(A) 16659 (B) 8477	Hubbell Hubbell	Twistlock 7057
11-108 Remote Control Unit	5-119 Remote Control Receptacle		49659	25 ft.	(A) 30774 (B) 38124-1 (C) 38108-1	Winchester Cannon Cannon	26S-6 AN3106B-24-28P AN3106B-18-8P

FIG. 7:01
REVISED 6-59

5-119P4 CABLE SCHEMATICS

PART VIII

PARTS LIST

A. REPLACEMENT PARTS ORDERING

A complete stock of spare and replacement parts is maintained for the 5-119P4 Oscillograph, and immediate shipment can be made at any time. All parts and assemblies which may possibly have to be replaced are identified in this section or on the schematic diagrams in this manual. The following information should be furnished at the time the order is placed:

1. Type of instrument and its serial number.

2. CEC part number, if one is so designated. If no number is shown, use the part symbol shown on the schematics.

3. Description of part or assembly desired.

4. Number of the drawing on which the part or assembly appears.

B. FACTORY REPAIRS

Repair or adjustment by inexperienced personnel should be avoided, and any major rework or adjustment should be accomplished either at the factory or by Consolidated's Field Service Engineers. Major repair by other than CEC personnel voids the warranty.

If serious trouble occurs, the instrument should be returned to the factory for repair or adjustment. Whenever possible, supplementary information, describing in particular the fault noted, etc., should accompany the instrument. This assures special attention to such items and greatly facilitates repair and consequent early return of the repaired instrument. All instruments returned to the factory for repairs or servicing should be properly identified by the owner's name and location, and an authorization or order to perform the necessary work should be sent at the same time to avoid delay.

All transportation charges are to be borne by the owner of the instrument.

C. FIELD SERVICE PLANS

Regular, scheduled maintenance service is available on a contract basis through CEC measuring and recording instrument service plans. Visits by a trained field service engineer may be scheduled two, three, or four times per one-year period and may be of whatever duration the amount of equipment demands. After every visit the user is given a detailed check list, including recommendations for operating procedure. Minor changes or modifications to improve the utility of the equipment for specific types of tests may be made by the field service engineer. Through such regular, preventive maintenance, long, trouble-free operation is assured at original standards of accuracy. See Appendix for Bulletins 1515 and 1303.

If equipment requires immediate attention, field service may be obtained on an emergency basis, and every effort is made to furnish the needed repairs as soon as possible after the malfunction occurs.

In the following parts list, those components designated by an asterisk (*) are on the Packing List as part of the initial shipment.

MODULAR BREAKDOWN

(Parts are listed for all modules)

Group	Item	Stock No.	Description	Page No.
A	*1	154600	5-119P4-36 Oscillograph Shell, 115v, 60 cps	8
	*2	154700	5-119P4-50 Oscillograph Shell, 115v, 60 cps	8
B	*1	154620	Dual Recording Lamps (Tungsten Filament)	13
	2	154610	Single Recording Lamps (Tungsten Filament)	
C	*1	154630	Slotted Disc Timing (standard unless otherwise specified	20
	2	154640	Master Electronic Flash Timing (can also be operated as slave - same as #41341)	21
	3	154650	Slave Electronic Flash Timing (same as #45480)	26
D	*1	154660	Polygon Scanning System (includes viewing)	15
	2	154670	Viewing System only	
E	*1	154680	Dual Counter System (Record & Event No.)	18
F	1	154740	Record Speed 0.1"/sec. to 100"/sec.	13
	*2	154750	Record Speed 0.16"/sec. to 160"/sec.	13
G	*1	154844	Vibration Isolator Base (same as #51111)	18
	2	154845	Base Plate	
H	*1	154720	Indicator Lamps (No Record, Recording, No Timing)	17
	2	154930	Indicator Lamps (No Record, Recording, No Timing); for use with #154640 and #154650 only.	28
I	*1	154730	Automatic Record Length	17

NOTES:

Group A - One must be selected
Group B - One must be selected
Group C - Select only one if required
Group D - One must be selected
Group E - Select only one if required
Group F - One must be selected
Group G - One must be selected
Group H - Select one if required, depending on selection in Group C
Group I - Select if required

* Makes up standard 5-119P4-36 or 50

REPLACEABLE PARTS AND OPERATING SUPPLIES

(The following parts are those most commonly required for maintenance and service. Prices are f. o. b. shipping point, and are subject to change without notice.)

MECHANICAL COMPONENTS

DESCRIPTION	PART NO.	UNIT PRICE
Belt, trace identifier (Gilmer)	31660	$ 2.20
Belt, trace identifier (interrupter pins)	31323	2.50
Chain, ladder	14205	.85 ft.
Contact Assembly, galvanometer	32467	3.00
Record Number Assembly	40176	
Actuator, switch (see print 40176)	39984	3.00
Actuator, switch (see print 40176)	39985	3.00
Arm, stud assembly (counter)	29396	5.50
Counter, bottom	39954	16.00
Counter, top	39953	16.00
Counter, visual	40060	33.00
Gear, spur	40037	5.00
Gear, spur, 20-tooth	14646	4.35
Gear, spur, 36-tooth	39876	8.00
Gear, spur, 36-tooth	7540	1.00
Mirror Assembly	40328	12.00
Scan Drive Assembly	30112	640.00
Gear, spur, 20-tooth	29894	10.50
Gear, spur, 60-tooth	29870	9.50
Gear, spur, 84-tooth	29869	7.50
Gear, spur, 124-tooth	29871	9.50
Gear, spur, 153-tooth	31537	8.75
Speed Change Gears		
Change Gear, 31-tooth	29694	6.50
Change Gear, 43-tooth	29695	6.50
Change Gear, 57-tooth	29847	5.50
Change Gear, 72-tooth	29846	7.50
Change Gear, 86-tooth	29692	12.00
Change Gear, 98-tooth	29693	16.00
Change Gear Knob	29696	1.70
Timing Motor Assembly	31354	425.00
Motor, a-c		7.50
Transmission Assembly		
Bearing, flanged	33859	1.50
Clutch, overriding, assembly	33623	55.00
Coupling, input shaft	37074	6.50
Pulley, transmission	30097	2.50
Record Length Control	29799	155.00
Actuator, switch	30707	1.40
Ring, retaining 0.188"		
0.125"		.05
Spring, return	30013	.30
Spring, torsion	30012	.60
Sprocket, 12-tooth	30564	1.70
Shaft, record drive	29978	14.00
Shockmount, transmission	29817	1.25

DESCRIPTION	PART NO.	UNIT PRICE
Spacer, change gear shaft	29754	$ 1.00
Spring, clutch release	30021	.60
Spring, record drive shaft	30020	.30
Fuse, 3AG, 2 amp	16656-32	.25
Fuse, 3AG, 3 amp	16656-33	.25
Fuse, 3AG, 10 amp	16656-35	.25
Illuminator, recording	21642	3.60
Illuminator, pilot, 12-16 v 0.1 amp	19785-2	.30
Illuminator, block heater, 12-16 v 0.1	19785-5	.30
Illuminator, meter	30748	.90

OPTICAL COMPONENTS

Lens, collimating	29832	33.00
Lens, dual counter	39836	3.25
Lens, polygon	29833	23.50
Lens, timing condensing	30213	7.75
Mirror, counter record	40322	4.00
Mirror, 1st timing	30201	9.00
Mirror, 2nd timing	39071	4.10
Mirror, 1st timing scan (front surface)	14742	2.20
Mirror, 2nd timing scan	30233	5.75
Mirror, 1st view	29742	3.50
Mirror, 2nd view	36791	9.00
Mirror, 2nd viewing (scan drive)	30202	8.00
Mirror, polygon (8 required)	29970	10.00
Prism, recording lamp (2 required)	29741	28.00
Screen, viewing	30017	22.00

It is recommended that optical system parts be replaced by CEC personnel only.

MAGAZINE MECHANICAL PARTS

Belt, drive (Gilmer)	37617	1.40
Cable Assembly, footage indicator	29922	3.25
Commutator, paper jam	30243	15.00
Brush Assembly, commutator	31176	8.00
Connector, 8 contact	31085	1.70
Cord Assembly, drag tension, 3-inch	30649-2	1.70
Cord Assembly, drag tension, 12-inch	30649-1	2.50
Gear, clash, 61-tooth, nylon (takeup and feed spool)	29839	6.50
Gear, helical, 23-tooth, bronze	29837	8.25
Gear, helical, 32-tooth, steel	29836	7.50
Pad, felt, clutch facing (Molykote saturated)	30044	.60
Potentiometer, 100 ohms, 2 watt	31254	1.90
Rack Assembly	30257	13.00
Shutter Pin	30253	3.30
Roller, metering	29969	29.50
Screw, lock, lid mounting	30317	8.00
Spool Assembly, takeup and feed	30597	60.00
Flange only	33168	10.00
Flange stop and paper guide	31257	12.00
Spring, drag, assembly	33734	1.90

DESCRIPTION	PART NO.	UNIT PRICE
Spring, drag tension	30803	$ .65
Spring, leading	29800	.30
Spring, magazine clutch	30660	.65
Spring, shutter locking	30804	.40
Tube, cardboard	31557	.20

MISCELLANEOUS PARTS

Battery, 1.3 volt (remote control)	27644	1.70
Card, galvanometer data, 36 trace	30459-3 & 4	.35
Card, galvanometer data, 50 trace	30459-1 & 2	.35
Case, galvanometer, 20 capacity	32488-2	12.00
Case, galvanometer, 30 capacity	32488-3	15.00
Dummy Galvanometer	7-003	15.00
Dynamic Reference Trace	7-004	120.00
Galvanometer Lifting Tool	31333	10.00
Illuminator, indicator (remote control)	30725-6	1.90
Lamp Removing Tool	34711	2.20
Manual, Operation and Maintenance	34620-2061	5.50
Oil, anti-rust, 2 oz.	33885	.90
Cover, protective dust	30155	4.40
Static Galvanometer Reference Trace	7-002	50.00
Switch, D.P.D.T. (S-102 remote control)	30770	4.10
Switch, (S-104, 105, 106 remote control unit)	30720	4.40
Switch, toggle, D.P.D.T. (S-103 remote control unit)	22461	3.90
Wrench, galvanometer lateral and timing line	21606	7.75
Wrench, galvanometer spot brilliance	31736	9.00
Cable Assembly, a-c power	49636	7.75
Plug, male	8477	1.40
Plug, twistlock	16659	1.10
Tab, cable (embossed 62)	63242-88	
Cable, 2 cond. #16	37560-3	

PHOTOGRAPHIC PROCESSING CHEMICALS

For 23-109A Oscillogram Processor		
Atkinson Concentrated Liquid Chemicals Kit	156455	5.75
DuPont Lino-Writ Rapid Processing Chemicals Kit (dry mix)	35131	5.75
For Manual Processing		
DuPont Lino-Writ Developer	33019	.55
DuPont Lino-Writ Fixer	33018	.70
Eastman Linagraph Developer	20393	.65
Eastman Linagraph Fixer	21947	.65

31470-1 RECORDING OSCILLOGRAPH ASSEMBLY

DESCRIPTION	PART NO.	NO. REQ'D.
Recording Oscillograph Assembly	31470-1	1
Structural Shell Assembly	31466	1
Panel, right side	29538	1
Panel, left side	29537	1
Angle, input panel	29840	1
Upper, end panel assembly	30168	1
Panel, upper	29848	1
Hinge, upper panel	30151	1
End panel upper	29845	1
Shield	30156	1
Plate, support	30071	1
Angle, galv. block cover	29850	1
Hinge, galv. block cover	29854	1
Cover, galv. block	29860	1
Scanning View Assembly	30138	1
Spring, catch (left)	30016-1	1
Screw, adjusting	30015	2
Scan View Door Assembly	29855	1
Door, scan viewing	29858	1
Hinge, scan view door	29857	1
Bar, mounting	29856	2
Panel, top (casting)	29591	1
Clamp, viewing screen	30254	8
Plate, cover	30314	1
Cover, rear panel	30376	1
Cover, filter	30166	1
Clip, filter	30394	4
Lower End Panel Assembly	42331	1
Isolator Base	51111	1
Gear and Hub Assembly, 98T	29693	1
Hub, gear	29701	1
Gear, change, 31T	29694	1
Gear, change assembly, 86T	154219	1
Blank, gear	154269	1
Hub, gear	154268	1
Gear, change 43T	29695	1
Gear and Hub Assembly, 72T	29846	1
Hub, gear	29701	1
Gear, change, 57T	29847	1
Filter	30398	1
Screen, viewing	30017	1

DESCRIPTION	PART NO.	NO. REQ'D.
Latch Assembly	30149	1
Bar, latch	30145	1
Cover Assembly, blower	42233	1
Screen	42232	1
Cover, blower	42321	1
Spacer	42318	3
Mounting Bracket, motor	42320	1
Fan, blower (4 blade)	41585	1
Motor, blower a-c (B-101)	39086	1

31468-1 AND -2 PLATFORM ASSEMBLY

Platform Assembly	31468-1 & 2	1
Bracket, relay mtg.	36741	1
Retainer Assembly	30470	1
Plate, spring retaining	30466	1
Pin, spring guide	30467	1
Shaft Assembly	30590	1
Shaft	30588	1
Pin coupling	30589	1
Timing Cover Assembly	30621	1
Plate	30410	1
Rack Assembly	30257	1
Rack, 32 pitch	30171	1
Pin, shutter	30253	1
Deck, casting	29447	1
Panel, front	29286	1
Clamp, cable 5/8	16786-9	4
Thermoswitch (S-105)	29819	1
Mount, 2nd timing mirror	39070	1
Hood, 2nd timing mirror	39072	1
Clamp, 2nd timing mirror	31678	2
Mirror, 2nd timing	39071	1
Mount, timing condensing lens	39073	1
Lens, timing condensing	30213	1
Capacitor, 1.0 mfd, 330v a-c	39109	1
Grommet	6887-23	1
Mirror, 1st timing	30201	1
Clamp, 1st timing mirror assembly	34591	1
Clamp, first timing mirror	30209	1
Bracket, adjustment first timing mirror	34588	1
Mirror, 1st timing scan	14742	1
Mount, motor	29592	1
Mount, instrument	20745-5	4
Belt, timing	37618	1
Bearing, flanged	30430	1
Bracket, magazine	30090	2
Mount, drive motor (rear)	30235	2
Spring, mag. release	51122	2
Resistor, 5 ohm, 30 W (R-130, R-131, R-133)	22465-23	3
Bracket, resistor mount	29612	2
Bracket Assembly	154631	1

DESCRIPTION	PART NO.	NO. REQ'D.
Bracket - hold down	42226	1
Bracket - support	42225	1
Bracket - angle	42350	1
Cover, record lamp	51235	2
Knob, lamp cover	51229	2
Receptacle (J-102)	31084	1
Retainer, filter	30915	1
Mount, collimating lens	30355	1
Lens, collimating	29832	1
Bracket, motor mount	29588	1
Bracket, motor relay	31961	1
Relay (K-103)	29121	1
Rollpin 1/2 x 9/16	22628-42	1
Coupling, motor	30360	1
Strip, terminal - 2 terminals	17252-2	1
Spring, motor shaft	30828	1
Plate, blower motor mount	42338	1
Transformer, power (T-101)	30273	1
Strip, terminal - 10 terminals	17252-10	1
Retainer, rack	30469	1
Index, magazine	30468	1
Guide, rack (left hand)	30237-1	1
Spring, compression	31683	1
Guide, rack (right hand)	30237-2	1
Clamp, cable	16786-6	1
Clamp, cable	16786-4	1
Clamp, cable	16786-2	1
Clamp, cable 1/4"	10525	1
Plate, identifier	31018	1
Plate, resistor mounting	33635	1
Plate, fuse mount	31592	1
Clamp, collimating lens	30373	2
Post, fuse (XF-101 through XF-106)	70001-3	6
Fuse, 3AG, 2 amp 250v (F-102)	16656-32	1
Fuse, 3AG, 10 amp 32v (F-106, 104, 101)	16656-35	3
Fuse, 3AG, 3 amp, 250v (F-103, 105)	16656-33	2
Relay (K-106, 109)	29202	2
Capacitor, 2 mfd, 600 w. v. (C-103)	70059-4	1
Resistor, 7.5 ohm, 10 w (R-149)	9612-5	1
Resistor, 50 ohm, 50 w (R-108, R-109)	29099	2
Rectifier (CR-101)	36742	1
Resistor, 25 ohm, 5 w (R-126, 127, 142)	22466-28	1
Plate, type and serial no.	32174	1
Plug	32647	4
Bracket, snubber	32951	1
Strip, terminal - 12 terminal	17252-12	1
Relay (K-101, 102)	33890	2
Mirror, 2nd view assembly	39960	2
Bar, mtg. - 2nd view mirror	39926	1
Mirror - 2nd view mirror	36791	2
Mount - 2nd view mirror	39927	2
Resistor, 200 ohm, 2 w (R-143)	7140-2015	1

DESCRIPTION	PART NO.	NO. REQ'D.
Resistor, 10K, ±10% 1/2 w (R-148, 101, 102, 114, 115, 153, 118, R-122, 128, 129)	7138-1031	6
Resistor, 10K, ±5%, 1/2 w (R-140)	7138-1035	1
Resistor, 1000 ohm, 1 w (R-154)	7139-1025	1
Varistor	33893	2
154662 SHELL ASSEMBLY MODULE		
Shell Assembly Module	154662	1
Recording Oscillograph Assembly	31470-1-4	1
Timing Motor Assembly	28897	1
Record Lamp Housing Assembly	30042	1
Scan Drive Assembly	30112	1
Control Panel Assembly	31465	1
Structural Shell Assembly	31466	1
Platform Assembly	31468	1
Record Number Assembly	40176	1
Transmission Assembly	43623	1
154600 OSCILLOGRAPH STRUCTURE ASSEMBLY		
5-119P4-36 Oscillograph Structure Assembly	154600	1
Shell Assembly Module	154662	1
Galvo. Block Assembly Module	36395	1
Galvo. Input Panel Assembly Module	31396	1
Galvo. Assembly, dynamic reference trace	35755	1
154700 OSCILLOGRAPH STRUCTURE ASSEMBLY		
5-119P4-50 Oscillograph Structure Assembly	154700	1
Shell Assembly Module	154662	1
Galvo. Block Assembly Module	36399	1
Galvo. Input Panel Assembly Module	30295	1
31396 GALVANOMETER INPUT PANEL MODULE - 36 TRACE		
Galvanometer Input Panel Assembly, 36 Trace	31396-1	1
Panel, galvanometer input 36 trace	29733-1	1
Receptacle, 3 contact (J-201 thru J-236 and J-261)	18290	37
Connector (J-101)	30290	1
Base motor, 2 prong	16949	1
Connector, 24 contact (J-103)	38024-4	1
Connector, 8 contact (J-104)	38008-4	1
Harness, galvanometer wiring	36245-C	1
Strip, fanning	29181	2
Contact Assembly	32467-15	14
Contact Assembly, galv.	32467-15	1
Clip, sleeve assembly	33033	28
Sleeve, contact	32462	28
Clip, contact	32463	28
Connector, right hand	32465	14
Connector, left hand	32466	14

DESCRIPTION	PART NO.	NO. REQ'D.
Clip, heater	30870	4
Cover, heater	30522	2
Sleeving, transparent	31365-12	As req'd.
Marker	8793-1 thru 37	1 each 37 total
Contact Assembly	32467-20	16
Contact Assembly	32467-24	7
Bar, bus 11 11/16	45974-2	2
Bar, bus 10	45974-3	1
Bar, bus 8 3/4	45974-4	1

36395 GALVANOMETER BLOCK ASSEMBLY MODULE - 36 TRACE

Galvanometer Block Assembly, 36 Trace	36395-1	1
Mounting Plate, galv..	29214	1
Galv. Magnet Sub Assembly, 18 trace	36394	2
Top Plate Assembly (front)	36391	1
Plate, top front	36390	1
Detent, galv.	35903-18	1
Mount, thermostat	35968	1
Top Plate Assembly (rear)	36393	1
Plate, top (rear)	36392	1
Guide, tool	29183	1
Spacer	29178	2
Plunger	29228	18
Retainer, 18 trace	29179	1
Retainer, spring	29180	1
Spring, galv.	35902-18	1
Bracket, static trace	29210	2
Washer, spring	28894	2
Clamp, static trace	29176	4
Mirror, post sub. assembly	29222	2
Mirror	6188	4
Cement, lens	17484-11	As req'd.
Post	29177	4
Side Plate	29182	2
Magnet, galv.	16922	1
Stud, galv. magnet mtg.	29209	2
Strip Identification (1-18)	29184	1
Strip Identification (19-36)	29211	1
Heater, cartridge, 115v a-c (R-106, 107)	20178	2
Thermostat (S-102, 103)	19016	2
Tape, elec., 1/2" wide	19784-9	As req'd.
Grommet, rubber 1/8 x 7/32	6887-29	2
Grommet, rubber 3/8 x 1/2	6887-1	1
Strip, terminal - 7 term.	17252-7	1
Strip, terminal - 3 term.	17252-3	1
Heater Clip Assembly	29368-2	1
Clip, heater	29366	1
Strap, mounting	29367	1
Heater Clip Assembly	29368-1	1
Clip, heater	29366	1
Strap, mounting	29367	1

DESCRIPTION	PART NO.	NO. REQ'D.
Heater, tubular 35 w 115v a-c (R-104, 105)	29369	2
Mirror Assembly, 2nd timing scan	31446	1
Cement, lens	17484-11	As req'd..
Mount	30212	1
Mirror	30233	1
Shield, terminal	32482	1
Plate, thermostat mount	31224	1
Lug, solder	7127-8	1
Clip, fuse	30708	2
Thermostat (S-104)	28458	1
Lug, hollow	15463-1	1
Spacer	42328	1

30295 GALVANOMETER INPUT PANEL MODULE - 50 TRACE

Galv. Input Panel Assembly, 50 Trace	30295-1	1
Panel, galv. input, 50 trace	29734-1	1
Receptacle, 3 contact (J-202 thru J-252)	18290	52
Connector (J-101)	30290	1
Base, motor, 2 prong	16949	1
Connector, 24 contact (J-103)	38024-4	1
Connector, 8 contact (J-104)	38008-4	1
Bar, bus 11 11/16	45974-1	4

36399 GALVANOMETER BLOCK ASSEMBLY MODULE - 50 TRACE

Galvanometer Block Assembly, 50 Trace	36399-1	1
Mounting Plate - galv.	29597	1
Galv. Magnet Sub-assem.	36396	2
Top Plate Assembly (front)	36398	1
Plate - top front	36400	1
Detent - galvanometer	35903-26	1
Mount, thermostat	35997	1
Extrusion	35967	As req'd.
Top Plate Assembly (rear)	36397	1
Top Plate (rear), 26 trace	36401	1
Spring, galvanometer (strip stop)	35902-26	1
Guide - tool	29446	1
Spacer	29178	2
Plunger	29228	26
Retainer, (26 trace)	29553	1
Retainer - spring (26 trace)	29549	1
Magnet - galvanometer	22804	1
Magnet - galvanometer	16820	1
Stud - mounting	29209	4
Side Plate	29543	2
Strip Identification (1-26)	29548	1
Strip Identification (26-50)	29550	1
Heater - cartridge (R-106, 107)	20178	2
Thermostat (S-102, 103)	19016	2
Mirror Assembly, 2nd timing scan	31474	1
Mount	30218	1

DESCRIPTION	PART NO.	NO. REQ'D.
Mirror	30233	1
Cement - lens	17484-11	As req'd.
Strip, terminal - 4 term.	17252-4	2
Strip, terminal - 3 term.	17252-2	1
Heater Clip Assembly	29571-1	1
Clip - heater	29366	1
Strap mounting	29551	1
Heater Clip Assembly	29571-2	1
Clip - heater	29366	1
Strap mounting	29551	1
Heater, tubular, 115v (R-104, 105)	29600	2
Heater, tubular, 24v (R-104, 105)	29601	2
Plate - thermostat mount	31480	1
Thermostat, miniature (S-104)	28458	1
Lug, hollow	15463-1	1
Clip, fuse	30708	2
Shield, terminal	32482	1

43623 TRANSMISSION ASSEMBLY

Transmission Assembly	43623	1
Housing, trans. (mach)	51189	1
Housing, transmission (casting)	51165	1
Plate, transmission	52020	1
Plate, shockmount	42021	1
Bar Transmission Mtg.	52022	2
Bearing, housing	29672	1
Shaft, A	37075	1
Shaft, B	37162	1
Shaft, C	29675	1
Shaft, D	37163	1
Shaft, E	29677	1
Shaft, F	29678	1
Shaft, G	29679	1
Shaft, H	29680	1
Shaft, worm	29681	1
Gear & Coupling Assembly	47117	1
Gear, blank	47112	1
Hub, coupling	47116	1
Gear & Pinion Assembly	47115	1
Gear, blank	47112	1
Gear, helical	47114	1
Gear, helical 24 T.	47113	1
Gear & Hub Assembly	29688	1
Hub, gear	29700	1
Overriding Clutch Assembly	33623	1
Roller, clutch	33629	3
Spring, roller	33630	3
Wire, music, .005 dia.	19568-2	As req'd.
Plate, clutch	33626	1
Gear and Ring 98T	37040	1
Plate, clutch	33627	1

DESCRIPTION	PART NO.	NO. REQ'D.
Cam, clutch	33628	1
Drum, clutch	37043	2
Gear & Pinion Assembly 91T	29687	1
Gear, helical 23T	29686	1
Hub, gear	29703	1
Gear, helical 31T	29684	1
Gear & Hub Assembly 98T	36583	1
Gear Assembly	37149	1
Rivet, flat hd. 3/32	19350-165	3
Gear, blank	36586	1
Hub, 98T gear	36587	1
Gear, 69T	154220	1
Gear, helical 29T	29682	1
Sleeve, spring	37044	1
Clip, plastic 3/16	16782-2	1
Nut, change gear	29696	3
Ring, spacer	29754	3
Key, change gear	29818	3
Bearing, ball	29780	1
Spring, bearing	29801	1
Bearing, ball	29781	8
Bearing, ball	29782	5
Spring, bearing	29800	8
Bearing, ball	29783	4
Spacer	37073	1
Shock Mount	29817	5
Ring, retaining . 156	21891-2	1
Ring, retaining . 913 O. D.	29602	8
Ring, retaining . 467 I. D.	29607	1
Solenoid Assembly	37049	1
Solenoid, rotary (L-703)	37101	1
Mount, solenoid	37042	1
Arm, clutch	37041	1
Pulley Assembly	30097	1
Flange, pulley	30033	2
Pulley, 11 groove	30093	1
Shaft Assembly Record Drive	29978	1
Pin, coupling	28346	2
Shaft	29976	1
Spring	30020	1
Solenoid, rotary	43668	1
Solenoid, rotary	37101	1
Brake Band Assembly	43662	1
Anchor Plate Assembly	43657	1
Link, anchor	43655	1
Plate, anchor	43656	1
Solder	18576-18	As req'd.
Flux	18576-27	As req'd.
Band, brake	43667	1
Lining, asbestos	43661	1
Sleeve, centering	33375	1
Plate, brake	43636	1

DESCRIPTION	PART NO.	NO. REQ'D.
Coupling, trans output	43669	1
Strip Insulator	43675	1
Ring, retaining	39832-125	1
Pin, anchor	43654	1
Molykote Type M-77	17484-32	As req'd.
Cover, transmission	51251	1
31465 CONTROL PANEL ASSEMBLY		
Control Panel Assembly	31465	1
Panel, control (finish detail)	154524	1
Panel, control	154523	1
Panel control (shell)	154398	1
Bushing, toggle switch	30542	2
Gasket, "O" Ring, .259 I. D.	15882-40	3
Switch, toggle D. P. D. T. (S-111)	42304	1
Switch, toggle D. P. D. T. (S-101)	43708	1
Meter, 0-30v d-c	36327	1
Lamp, meter (I-110)	30748	1
Ring, retaining .125	24189-4	1
Lens, counter view	30706	1
Spring, reset locking	40744	1
154740 RECORD SPEED - 5000 RPM MODULE		
Record Speed, 5000 rpm (module)	154740	1
Motor, record speed (B-103)	29126	1
Brush, motor	29126-1	2
Governor	29126-2	1
Brush, governor	29126-3	2
Plate, change gear	30358	1
154750 RECORD SPEED - 8000 RPM MODULE		
Record Speed, 8000 rpm (module)	154750	1
Motor, record speed (B-103)	45477	1
Brushes, motor	29126-1	2
Governor	45477-1	1
Brushes, governor	29126-3	2
Plate, change gear	51154	1
154620 DUAL RECORDING LAMPS MODULE		
Dual Recording Lamps (module)	154620	1
Record Lamp Housing Assembly	30042	1
Painting Inst. (housing record lamp)	154371	1
Housing, record lamp	29388	1
Housing record lamp	154164	1
Record Lamp Assembly	29739	2
Record lamp mounting	29279	1
Mount, mirror	29398	1
Shield	29745	2
Prism, recording lamp	29741	1
Mirror	29742	1
Clip, mirror	29397	2
Contact	29743	4
Mount, contact	31345	2
Clamp, prism	29744	1
Pin, index	28973	6

DESCRIPTION	PART NO.	NO. REQ'D.
Ring, retaining .062 dia.	24189-2	6
Lamp (L-102, 103, 104, 105)	21642	2
Cushion, mirror	30007	1
Baffle, light	31347	2
"Cone-Trol" Assembly	49454	1
Bracket, mounting	49437	1
Insert, expansion	49287	8
Cover, "Cone-Trol"	49445	1
Knob	51135	2
Spring "Cone-Trol"	51136	2
Gasket "O" Ring .737	15882-49	2
Actuator (rework)	30252	4
Actuator, microswitch	30707	4
Microswitch, S.P.D.T. (S-112 thru S-115)	36872	4
Insulator	36195	1
Potentiometer, 25 ohm 25 w ±10% (R-124, 125)	31304	2
Plate, trace identifier mtg.	29655	1
Plate, aperture	30028	2
Plate, relay mtg.	30056	1
Relay (K-107, 108)	30038	2
Tape, cambric	42418-1	4"
Belt, trace identifier	31323	1
Pin, trace identifier	31329	2
Angle, guide	31324	1
Washer, flat #4	70077-94	3
Pulley, driven	31326	1
Pin, pulley	31328	1
Ring, retainer ext. .250	24189-8	1
Washer	31327	3
Pulley, driver	31325	1
Pulley, assembly	30031	1
Pulley, timing belt	30032	1
Flange	30033	2
Sleeve, trace identifier	30034	1
Bushing, sleeve	25850	2
Shaft, trace identifier	30035	1
Relay Record (K-106)	29202	1
Resistor, 25 ohm 5 w (R-126, 127)	22466-28	2
Lens Holder	31481	4
Light Rod #1	31522	1
Light Rod #2	31520	1
Light Rod #3	33381	1
Light Rod #4	31521	1
Resistor, 9.5 ohm 10 w (R-146, 147)	9612-6	2
Resistor, 3.8 ohm 10 w (R-138, 145)	9612-4	2
Resistor, 5 ohm 30 w (R-130)	22465-23	1
Resistor, 5 ohm 30 w (R-131)	22465-23	1
Switch - pushbutton D.P.D.T. (S-120)	33875	1

DESCRIPTION	PART NO.	NO. REQ'D.
154660 POLYGON SCANNING SYSTEM MODULE		
Polygon Scanning System Module	154660	1
Scan Drive Assembly	30112	1
End plate (mach)	29738-1	1
End plate casting	51798	1
Mount mirror, 2nd viewing	29752	1
Mirror, 2nd viewing	30202	1
Cement - lens	17484-11	As req'd.
Plate, top	29755	1
Plate, end scan view	29761	1
Stop, index lever	29966	1
Bracket, spring retainer	29967	1
Shaft, polygon	30027	1
Mirror, polygon	29970	8
Detent, polygon lock	29963	1
Cover, scan view mirror	29997	1
Polygon indexing assembly	30072	1
Lever, polygon	29954	1
Pin, polygon lock	29964	1
Hub, lever	29965	1
Mount, lens	29947	2
Lens, polygon	29833	1
Spring, retainer, lens	29946	2
Spring, detent	30094	1
Bearing . 189 x . 314 x . 250	25850-3	2
Plate, inner	30115	1
Gear, spur 60T.	29870	1
Hub, gear mount	29868	1
Gear, spur 124T	29871	1
Bearing, flanged	30325	1
Shaft, gear drive	31559	1
Gear, spur 84T	29869	1
Gear, drive 20T	29894	1
Detent, ball	28443	1
Spring, detent	29900	1
Plate, outer	29920	1
Motor, scan drive (B-104)	29803	1
Gear, spur 57T, part of B-29803	31538	1
Cover, polygon	29773	1
Clip, mirror retaining	30100	2
Pad, mirror	30129	2
Pin, drive	30326	1
Shaft, lens view	29909	1
Clip, mounting	33886	3
Shield, polygon cover	30971	1
Lockwasher, int. #2	7058-41	6
Bearing, flanged	31574	1
Gear, spur 153T	31537	1
Hub, gear	32816	1
End, plate (mach)	29738-2	1
End plate casting	51798	1

DESCRIPTION	PART NO.	NO. REQ'D.
Clip, cover	29394	1
Clip, galv. lifting tool	32956	9
Clip	30708	9
Scan Drive Assembly	154842	1
End Plate, rework, left	154399-1	1
Casting end plate	29738-1	1
Mount Mirror, 2nd viewing	29752	1
Mirror, 2nd viewing	30202	1
Cement, lens	17484-11	As req'd.
Plate, top	29755	1
Plate, end scan view	29761	1
Stop, index lever	29966	1
Bracket, spring retainer	29967	1
Shaft, polygon	30027	1
Mirror, polygon	29970	8
Detent, polygon lock	29963	1
Cover, scan view mirror	29997	1
Polygon Indexing Assembly	30072	1
Lever, polygon	29954	1
Pin, polygon lock	29964	1
Hub, level	29965	1
Solder, silver 1/32 dia.	18576-12	As req'd.
Mount, lens	29947	2
Lens, polygon	29833	1
Spring, retainer, lens	29946	2
Spring, detent	30094	1
Bearing .189 x .314 x .250	25850-3	2
Plate, inner	30115	1
Gear, spur 60T	29870	1
Hub, gear mount	29868	1
Gear, spur 124T	29871	1
Bearing, flanged	30325	1
Shaft, gear drive	31559	1
Gear, spur 84T	29869	1
Gear, drive 20T	29894	1
Detent, ball	28443	1
Spring, detent	29900	1
Standoff	30051	4
Plate, outer	29920	1
Motor, scan drive (B-103)	29803	1
1 set motor brushes norm. alt.	29803-1	1
Gear, spur 57T (Part of B-29803)	31538	1
Cover, polygon	40599	1
Clip, mirror retaining	30100	2
Pad, mirror	30129	2
Strip, terminal - 2 term.	27025-2	1
End Plate	154399-2	1
Clip Cover	29394	1
Clip - galv. lifting tool	32956	6
Knob	51135	1
Knob & Dial Plate Assembly	70115-1	1
Spring "Cone-Trol"	51136	1

DESCRIPTION	PART NO.	NO. REQ'D.
Gasket, "O" ring	15882-49	1
Pot, 500 ohm 4 w (S-125, S-114) (R-139, R-117)	31305	1

154720 INDICATOR & WARNING LAMPS MODULE

Indicator & Warning Lamps Module	154720	1
Indicator Lamp Assembly	30737	1
Window, indicator lamp	40832	1
Socket, brkt. mtg. (XI-107, 108, 109)	30751	3
Frame, indicator lamp	30526	1
Window, indicator lamp	40833	1
Window, indicator lamp	40834	1
Retainer, filter	30603	4
Mount, lamp socket	31981	1
Eyelet	21925	4
Lamp, G-3-1/2 (I-107, 108, 109)	19785-2	3
Shield	44252	1
Rectifier (CR-106, 107, 108, 109)	29824	4
Resistor, fixed 200 ohm, 5 w (R-144)	22466	1
Resistor, 50 ohm 25 w (R-123)	14296-9	1
Switch - pushbutton, D.P.D.T. (S-124)	33875	1
Lamp, 12-16v .10 amp (I-101)	19785-5	1
Socket, pilot lamp (XI-101)	31625	1
Resistor, 10 ohm 5w (R-103a and R-103b)	22466-4	2
Relay (JAM) (K-104, 105)	29120	2
Resistor, 100 ohm 2 w (R-119, 120)	7140-1011	2
Capacitor, 100 mfd, 50 wv (C-106, 109)	29200	2
Capacitor, 100 mfd, 50 wv (C-107, 108)	29200	2

154730 AUTO. RECORD LENGTH CONTROL MODULE

Auto. Record Length Control Module	154730	1
Auto. Record Length Control Assembly	154311	1
Plate, mounting	154299	1
Plate, mounting (mold)	154298	1
Shaft, arm ratchet	154303	1
Pin, spring	154304	1
Pin, spring solenoid	154305	1
Plate, sleeve	154301	1
Plate, sleeve	154300	1
Pin, stop	154321	1
Lever, ratchet	154302	1
Rotary, solenoid (L-101)	29106	1
Cam	154310	1
Spring	154309	1
Switch, micro	70087-7	2
Actuator, microswitch	30707	1
Bracket, switch mtg.	33860	1
Spring, return	30013	1
Sprocket, 12T	45844	1
Screw, adjust	154320	2
Spring, drag	154308	2

DESCRIPTION	PART NO.	NO. REQ'D.
Plug, drag	29919	2
Pin, shaft stop	32906	1
Shaft, differential	29890	1
Bearing, flanged	30011	1
Gear	154172	1
Gear, bevel	7542-1	1
Spacer	29729	2
Shaft, pinion	29723	1
Gear, bevel (pinion)	7542-2	1
Gear, bevel	29926	1
Gear, bevel	7542-1	1
Gear, helical	29735	1
Pin, gear stop	29912	1
Spring, torsion	30012	1
Bushing Assembly	154312	1
Bushing	154306	1
Bearing	154307	1
Pin	29913	1
Pin stop	29921	1
Ring, retaining	24189-4	2
Ring, retaining	21891-3	1
Auto. Record Length Control Shaft Assembly	30473	1
Bracket, support	30475	1
Sprocket	45844	1
Sprocket	30564	1
Joint, universal	30559	1
Joint, universal	14047	1
Shaft, record length control	30472	1
Shaft, record length control	30471	1
Bearing, flanged	30427	1
Spring, tension	31679	1
Chain, ladder	14205	7 3/4" approx.
Switch, toggle D.P.3T. (S-106)	42305	1
Bushing	25933	1
Rectifier, (CR-103, 104, 105)	29824	3
Resistor, 10K 1/2 w (R-115)	7138-1031	1
Cover, transmission	29669	1

154844 VIBRATION ISOLATOR BASE MODULE

Vibration Isolator Base Module	154844	1
Isolator Base	51111	1

154680 RECORD & EVENT NUMBERING MODULE

Record & Event Numbering Module	154680	1
Record Numbering Assembly	40176	1
Casting, dual counter	39792	1
Solenoid Base Assembly	40097	1
Bracket, solenoid	39913	1
Bracket, solenoid (#4)	39914	1
Base, solenoid	39957	1
Arm, stud assembly	29396	1

DESCRIPTION	PART NO.	NO. REQ'D.
Arm, counter	29295	1
Stud, link	29299	1
Arm, stud assembly	40174	1
Stud, link	29299	1
Arm, counter (dual)	40025	1
Stud, link	40042	1
Arm, stud assembly	40175	1
Arm, counter	40026	1
Stud, link	40043	1
Base Plate & Counter Assembly	40060	1
Counter	26449	1
Plate-view counter	39921	1
Clamp Assembly (flash tube)	39989	1
Counter, top (A-29431)	39953	1
Counter - ratchet	29431	1
Counter, bottom (A-29431)	39954	1
Counter - ratchet	29431	1
Stud, gear (20 teeth)	39920	2
Stud, gear (36 teeth)	39919	1
Gear, (36 teeth)	39876	2
Gear, spur A-10476	40037	1
Gear, spur with hub	10476	1
Paint, stick, engraving, filler	0128-6	As req'd.
Gear, spur G-134 (20 teeth)	14646	2
Gear, spur G-139 (36 teeth)	7540	1
Lens, dual counter	39836	1
Link, solenoid	39915	1
Link, counter	39917	1
Link, solenoid	39916	1
Actuator, switch	39984	1
Actuator, switch	39985	1
Bracket, microswitch mtg.	48089	1
Actuator, switch	40044	1
Holder, lens	39956	1
Solenoid, rotary (A-40107) (L-105)	40324	1
Solenoid, rotary	40107	1
Solenoid, rotary (A-37181) (L-106)	40326	1
Solenoid, rotary	37181	1
Microswitch(S-128, 129, 130)	36872	3
Actuator	30707	3
Ring, retaining (3/16)	24189-7	1
Plug, knob	39986	3
Retainer, lens	29294	1
Plate, serial no.	40327	1
Disc, aperture	40323	1
Mirror Assembly	40328	1
Mount, mirror	40276	1
Mirror	40322	1
Flashtube Assembly	29300	1
Flashtube Sub-assembly	34822	1
Flashtube (rework) (V-101)	34827	1
Flashtube	26734	1

DESCRIPTION	PART NO.	NO. REQ'D.
Ionizer	34825	1
Wire, braided	34823	6"
Transformer, ignition (T-102)	34820	1
Terminal	34826	4
Wire, braided	34823	As req'd.
Board, mounting	51882	1
Compound - "Epocast" #9A	17875-20	As req'd.
Bead, glass	154379	As req'd.
Sleeving, fiber glass (I. D.) (.038)	24400-19	As req'd.
Spring, helical, tension	48097	1
Rectifier (CR-115)	27116	1
Capacitor, 2 mfd, 1000 wv (C-104)	154354	1
Capacitor, 1 mfd, 400 wv (C-105)	35062	1
Resistor, 470K 1/2 w (R-112)	7138-4741	1
Resistor, 33K 1 w (R-113)	7139-3331	1
Resistor, 750K 1 w (R-111)	7139-7545	1
Resistor, 10K 2 w (R-110)	7140-1035	1
Rectifier, selenium (CR-110)	29104	1
Rectifier Mount Assembly	30261	1
Stud, #8-32 x 1/2	29842-5	2
Post, nylon	42377	2
Rectifier, (CR-111, 112, 113)	29824	3
Component Board Assembly	41411	1
Terminal Board Assembly	41409	1
Bracket, mounting	41407	1
Board, terminal	41408	1
Resistor, 10K 1/2 w 10% (R-116)	7138-1031	1
Resistor, 50 ohms 10 w (R-152)	9557-7	1

154630 SLOTTED DISC TIMING MODULE

Slotted Disc Timing Module	154630	1
Timing Motor Assembly	28897	1
Angle, left	28892	1
Plate, top	28896	1
Plate, spacer	28895	1
Plate, bottom	28899-1	1
Stand off	28891	4
Screw, adj. assembly	28883	1
Base, lamp mounting	28898	1
Contact	28889-2	1
Contact	28889-1	1
Shutter	39067	1
Angle, right	28893	1
Spacer	28885	1
Spring	28886	2
Tubing, Neoprene	46399	1
Flange, shaft assembly	28980-3	1
Flange	28884	1
Shaft	48290	1
Shim	28888-1, 2, 3	3
Lamp (install on final assembly (I-106)	21642	1

DESCRIPTION	PART NO.	NO. REQ'D.
Blanking, disc.	28900	1
Disc, timing	28901	1
Pin	28880	1
Bearing, ball	28970	2
Motor, timing, a-c (B-102)	28969	1
Spring, index pin 19568-15	28971	3
Pin, index	28973	3
Washer, flat #2	70077-91	6
Ring, retaining .062	24189-2	3
Ring, retaining .125	24189-4	1
Switch, micro S. P. D. T. (S-121, 122)	36872	2
Potentiometer, 25 ohm 25 w (R-132)	31304	1
Resistor, 5 ohm 30 w (R-133)	22465-23	1
Resistor, 7.5 ohm 10 w (R-149)	9612-5	1

154640 MASTER ELECTRONIC FLASH TIMING MODULE

Master Electronic Flash Timing Module	154640	1
Electronic Timing Kit	45529	1
Slave Unit Assembly	41118	1
Board, mounting	44231	1
Transformer, power (T-202)	40888	1
Flashtube assembly (E-202)	40855	1
Flashtube	40903	1
Flashtube	40896	1
Connector, pin	40852-1	3
Holder, flashtube	40850	1
Plastic compound, PR-906	17875-22	As req'd.
Transformer assembly (potted)	40853	1
Housing, transmission	40712	1
Housing, transmission, molding	40851	1
Connector, socket	40852-2	3
Transformer, ignition (T-201)	41004	1
Lug, spade min.	41532-5	2
Lug, solder (flat)	7127-11	2
Aperture, plate	40948	1
Spring, compression	40515	2
Capacitor, 10-40 mfd 450v d-c (C-232)	40658	1
Connector, pins (J-201)	41313-2	1
Capacitor, 80 mfd 350v (C-233, 234)	40657	2
Capacitor, 1.0 mfd 200v (C-235)	40714	1
Lamp, indicator (neon) (I-202)	40854	1
Aperture, strip	40594	2
Capacitor, .25 - .25 600v dual (C-231)	41237	1
Tube, electronic 2D21W (V-212, 213)	70091-124	2
Shield, tube 7 pin min.	70113-2	2
Shield, lamp, indicator	49900	1
Terminal, lug solder	7127-9	1
Standoff, #4-40 x 3/8	6889-24	2
Wafer, mounting	52069	3
Terminal, lug, solder	7127-34	1
Capacitor, .01 mfd 400v d-c 20% (C-227)	40646-4	1

DESCRIPTION	PART NO.	NO. REQ'D.
Capacitor, .01 mfd 400v d-c 20% (C-230, 229)	40646-4	1
Capacitor, .047 mfd 600v d-c 10%	40650	1
Resistor, 12K 5 w 1% (R-273)	70026-1202	1
Resistor, 10 ohm 1 w 5% (R-290)	7139-1005	1
Rectifier, 1N589 (CR-208)	40893-2	1
Rectifier, 1N589 (CR-209)	40893-2	1
Rectifier, 1N589 (CR-210)	40893-2	1
Rectifier, 1N589 (CR-211)	40893-2	1
Resistor, 510K 1/2 w 5% (R-275)	7138-5145	1
Resistor, 510K 1/2 w 5% (R-276)	7138-5145	1
Resistor, 510K 1/2 w 5% (R-269)	7138-5145	1
Resistor, 10K 1/2 w 5% (R-272)	7138-1035	1
Resistor, 51K 2 w 5% (R-271)	7140-5135	1
Resistor, 51K 1/2 w 5% (R-270)	7138-5135	1
Resistor, 120K 1 w 5% (R-277)	7139-1245	1
Resistor, 2.0K 5 w 10% (R-278)	22466-23	1
Resistor, 270K 1/2 w 5% (R-280)	7138-2745	1
Resistor, 270K 1/2 w 5% (R-279)	7138-2745	1
Resistor, 270K 1/2 w 5% (R-281)	7138-2745	1
Resistor, 4.7K 1/2 w 5% (R-282)	7138-4725	1
Resistor, 270K 2 w 5% (R-283)	7140-2745	1
Resistor, 2.4 meg 1/2 w 5% (R-286)	7138-2455	1
Resistor, 47 ohm 1/2 w 5% (R-291)	7138-4705	1
Resistor, 120 ohm 1/2 w 5% (R-292)	7138-1215	1
Resistor, 10 ohm 1/2 w 5% (R-274)	7138-1035	1
Oscillator Assembly	41117	1
Chassis, oscillator	40522	1
Parallel resonant circuit (Z-201)	41028	1
Connector, plug 7 pin (J-202)	41181-2	1
Tube, electronic 5963 (V-201, 202)	7016-5963	2
Socket, electron tube 9 contact	70111	2
Shield tube, 9 pin min.	0114-2	2
Standoff, insulated (4-40 thd.)	14477-4	4
Clamp, spring	31029-2	2
Capacitor, silver mica 5% (C-228)	39412	As req'd.
Capacitor, .1 mfd 400v (C-201)	40646-1	1
Capacitor, .1 mfd 400v (C-202)	40646-1	1
Capacitor, .022 mfd 400v (C-236)	33004-2231	1
Diode, 1N231 (CR-201)	45514	1
Resistor, 470K 1/2 w 5% (R-201)	7138-4745	1
Resistor, 470K 1/2 w 5% (R-202)	7138-4745	1
Resistor, 1 meg 1/2 w 5% (R-288)	7138-1055	1
Resistor, 1 meg 1/2 w 5% (R-289)	7138-1055	1
Resistor, 1 meg 1/2 w 5% (R-202)	7138-1055	1
Resistor, 1 meg 1/2 w 5% (R-207)	7138-1055	1
Resistor, 100K 1 w 5% (R-203)	7139-1045	1
Resistor, 100K 1 w 5% (R-205)	7139-1045	1
Resistor, 1K 1/2 w 5% (R-204)	7138-1025	1
Resistor, 51K 1/2 w 5% (R-287)	7138-5135	1
Resistor, 51K 1/2 w 5% (R-208)	7138-5135	1
Decal, component identification	46977	1

DESCRIPTION	PART NO.	NO. REQ'D.
Upper & Lower Panel Assembly	40524	1
Panel, upper	40525	1
Hinge, upper panel	30151	1
End panel, upper	40526	1
Shield	30156	1
Plate, support	30071	1
Angle, galvanometer block cover	29850	1
Hinge, block cover	29854	1
Cover, galvanometer block	29860	1
Bracket, panel (upper)	40518	4
Bracket, panel (lower)	40517	4
Plate, reflector	40590	1
Insulator, asbestos	41159	1
Latch assembly	30149	1
Stud	30144	1
Latch bar	30145	1
Grommet, stud	30169	1
Panel, connector	41158	1
Receptacle	40665	3
Cover, polygon	40599	1
Electronic Timing Pr. Wr. Bd. Assembly	40711	1
Printed wiring bd. - detail	40710	1
Bracket, tube	40520	1
Cover tube bracket	40519	1
Clamp, tube	41141	2
Terminal, standoff	14477-6	2
Socket, tube, 8 contact	0107	2
Clip, tube "2"	154989	7
Clip, tube "2"	41227	7
Spring, detent	40894	2
Shaft, switch	40895	2
Socket, tube 9 pin min.	40666	7
Switch, wafer assembly	52060	2
Knob & Dial Pointer Assembly	70115-7	2
Knob	70100-14	2
Dial pointer	70105-3	2
Capacitor, .10 mfd 400v (C-203)	40646-1	1
Capacitor, 270 mmfd 500v (C-205)	39412-2705	1
Capacitor, 330 mmfd 500v (C-206)	39412-3305	1
Capacitor, 330 mmfd 500v (C-207)	39412-3305	1
Capacitor, 680 mmfd 500v 5% (C-208)	70013-6815	1
Capacitor, .0022 mfd 400v 20% (C-209)	40646-3	1
Capacitor, 4 mfd 450v (C-210)	40661	1
Capacitor, 10 mfd 100v (C-211)	40662	1
Capacitor, 270 mmfd 500v (C-212)	39412-2705	1
Capacitor, .01 mfd 400v 20% (C-213)	40646-4	1
Capacitor, .01 mfd 400v 20% (C-214)	40646-4	1
Capacitor, .033 mfd 100v 20% (C-215)	40647	1
Capacitor, 100 mmfd 500v 5% (C-216)	39412-1005	1
Capacitor, 330 mmfd 500v (C-217)	39412-3305	1
Capacitor, 100 mmfd 500v 5% (C-218)	39412-1005	1
Capacitor, 330 mmfd 500v (C-219)	39412-3305	1

DESCRIPTION	PART NO.	NO. REQ'D.
Capacitor, .001 mfd 400v (C-220)	40646-2	1
Capacitor, .001 mfd 400v (C-221)	40646-2	1
Capacitor, .0022 mfd 400v 20% (C-222)	40646-3	1
Capacitor, 270 mmfd 500v (C-223)	39412-2705	1
Capacitor, .01 mfd 400v 20% (C-224)	40646-4	1
Capacitor, .01 mfd 400v 20% (C-225)	40646-4	1
Capacitor, .033 mfd 100v 20% (C-226)	40647	1
Diode, 1N302 (CR-203)	42810	1
Diode, 1N302 (CR-204)	42810	1
Diode, 1N302 (CR-205)	42810	1
Diode, 1N302 (CR-206)	42810	1
Diode, 1N302 (CR-207)	42810	1
Resistor, 220K 1/2 w 5% (R-209)	7138-2245	1
Resistor, 75K 1/2 w 5% (R-210)	7138-7535	1
Resistor, 30K 1 w 5% (R-211)	7139-3035	1
Resistor, 10K 1/2 w 5% (R-212)	7138-1035	1
Resistor, 20K 1 w 5% (R-213)	7139-2035	1
Resistor, 470K 1/2 w 5% (R-214)	7138-4745	1
Resistor, 20K 1 w 5% (R-215)	7139-2035	1
Resistor, 270K 1/2 w 5% (R-216)	7138-2745	1
Resistor, 100K 1/2 w 5% (R-217)	7138-1045	1
Resistor, 270K 1/2 w 5% (R-218)	7138-2745	1
Resistor, 22K 1/2 w 5% (R-219)	7138-2235	1
Resistor, 62K 1/2 w 5% (R-220)	7138-6235	1
Resistor, 5.6K 1/2 w 5% (R-221)	7138-5625	1
Resistor, 33K 2 w 5% (R-222)	7140-3335	1
Resistor, 10K 1/2 w 5% (R-223)	7138-1035	1
Resistor, 1.0 meg 1/2 w 5% (R-224)	7138-1055	1
Resistor, 510K 1/2 w 5% (R-225)	7138-5145	1
Resistor, 100K 1/2 w 5% (R-226)	7138-1045	1
Resistor, 68K 2 w 5% (R-227)	7140-6835	1
Resistor, 5.1K 1/2 w 5% (R-228)	7138-5125	1
Resistor, 5.1K 1/2 w 5% (R-229)	7138-5125	1
Resistor, 20K 1 w 5% (R-230)	7139-2035	1
Resistor, 10K 1/2 w 5% (R-231)	7138-1035	1
Resistor, 20K 1 w 5% (R-232)	7139-2035	1
Resistor, 10K 1/2 w 5% (R-233)	7138-1035	1
Resistor, 1.0 meg 1/2 w 5% (R-234)	7138-1055	1
Resistor, 390K 1/2 w 5% (R-235)	7138-3945	1
Resistor, 390K 1/2 w 5% (R-236)	7138-3945	1
Resistor, 1.0 meg 1/2 w 5% (R-237)	7138-1055	1
Resistor, 680K 1/2 w 5% (R-238)	7138-6845	1
Resistor, 68K 1/2 w 5% (R-239)	7138-6835	1
Resistor, 100K 1/2 w 5% (R-240)	7138-1045	1
Resistor, 1.2 meg 1/2 w 5% (R-241)	7138-1255	1
Resistor, 100K 1/2 w 5% (R-242)	7138-1045	1
Resistor, 62K 1/2 w 5% (R-243)	7138-6235	1
Resistor, 5.6K 1/2 w 5% (R-244)	7138-5625	1
Resistor, 33K 2 w 5% (R-245)	7140-3335	1
Resistor, 1.0 meg 1/2 w 5% (R-246)	7138-1055	1
Resistor, 10K 1/2 w 5% (R-247)	7138-1035	1
Resistor, 100K 1/2 w 5% (R-248)	7138-1045	1
Resistor, 62K 1/2 w 5% (R-249)	7138-6235	1

DESCRIPTION	PART NO.	NO. REQ'D.
Resistor, 39K 2 w 5% (R-250)	7140-3935	1
Resistor, 1.0 meg 1/2 w 5% (R-251)	7138-1055	1
Resistor, 10K 1/2 w 5% (R-252)	7138-1035	1
Resistor, 470K 1/2 w 5% (R-253)	7138-4745	1
Resistor, 20K 1/2 w 5% (R-254)	7138-2035	1
Resistor, 470K 1/2 w 5% (R-255)	7138-4745	1
Resistor, 20K 1/2 w 5% (R-256)	7138-2035	1
Resistor, 510K 1/2 w 5% (R-257)	7138-5145	1
Resistor, 100K 1/2 w 5% (R-258)	7138-1045	1
Resistor, 20K 1 w 5% (R-259)	7139-2035	1
Resistor, 10K 1/2 w 5% (R-260)	7138-1035	1
Resistor, 20K 1/ w 5% (R-261)	7139-2035	1
Resistor, 10K 1/2 w 5% (R-262)	7138-1035	1
Resistor, 1.0 meg 1/2 w 5% (R-263)	7138-1055	1
Resistor, 390K 1/2 w 5% (R-264)	7138-3945	1
Resistor, 390K 1/2 w 5% (R-265)	7138-3945	1
Resistor, 1.0 meg 1/2 w 5% (R-266)	7138-1055	1
Resistor, 680K 1/2 w 5% (R-267)	7138-6845	1
Resistor, 68K 1/2 w 5% (R-268)	7138-6835	1
Switch (S-201)	52060	1
Wafer switch	52058	1
Contact wiper	52059	4
Switch (S-202)	52060	1
Wafer switch	52058	1
Contact wiper	52059	4
Tube, electronic 5963 (V-203)	7016-5963	1
Tube, electronic 5963 (V-204)	7016-5963	1
Tube, electronic 5963 (V-205)	7016-5963	1
Tube, electronic 6802 (V-206)	7016-6802	1
Tube, electronic 5963 (V-207)	7016-5963	1
Tube, electronic 5963 (V-208)	7016-5963	1
Tube, electronic 5963 (V-209)	7016-5963	1
Tube, electronic 5963 (V-210)	7016-5963	1
Tube, electronic 6802 (V-211)	7016-6802	1
Timing Cover Assembly	40542	1
Plate, change gear	40547	1
Spacer, change gear	30412	2
Stop, spare lamp	40529	1
Clip	32956	3
Clip, mounting	33886	2
Standoff, 1/4 D. A. x 1/4	47036	1
Standoff	6888-1	1
Clamp, loop type support	16786-3	3
Clip	32956	6
Plate, test button	41160	1
Plate, type & serial no.	32174	1
Pin, escutcheon 3/16	7162-590	4
Cable, interconnecting	49694	3
Plug, coaxial	40664	2
Cable, coaxial	45601	As req'd.
Adapter, tee coaxial	45744	3
Bracket, oscillator	41084	1

DESCRIPTION	PART NO.	NO. REQ'D.
Bracket, slave unit	40997	1
Bracket, rectifier	40513	1
Galvanometer Wrench Assembly	40596	1
Galvanometer wrench sub-assembly	40595	1
Galvanometer wrench body	28035	1
Pin	28036	1
Sleeve, tool	31735	1
Condensing Lens Assembly	40700	1
Lens, condensing (timing)	41012	1
Plate, aperture	40900	1
Mount, condensing lens (timing)	40668	1
Cable Assembly	40514	1
Connector, hood	41313	1
Connector, socket (female) (P-201)	41313-1	1
Connector, hood	41181-3	1
Connector, socket (female) (P-202)	41181-1	1
Clamp, loop type support	16786-6	2
Strip, taper	47074	2
Cover, taper strip	47075	1
Dual Taper Connector	37082-4	5
Connector, taper pin	36966-4	10
#6-32 x 1/2 Ph. Bd. Hd. M. S.	14050-3465	2
Board, insulation	45760	1
Washer, extruded	7164-6	2
Lubricant, DC-11	15821-37	As req'd.
Rectifier, silicon junction	45753	2
Manual, instruction	34620-2113	1

154650 SLAVE ELECTRONIC FLASH TIMING MODULE

Slave Electronic Flash Timing Module	154650	1
Slave Electronic Timing Kit	48020	1
Slave Unit Assembly	49925	1
Board, mounting	44231	1
Transformer, power (T-202)	40888	1
Flashtube assembly (E-202)	40855	1
Flashtube	40903	1
Holder, flashtube	40850	1
Transformer assembly (potted)	40853	1
Housing, transmission	40712	1
Housing, transmission, molding	40851	1
Connector, socket	40852-2	3
Transformer, ignition (T-201)	41004	1
Aperture, plate	40948	1
Spring, compression	40515	2
Connector, pins (J-201)	41313-2	1
Capacitor, 80 mfd 350v (C-233, 234)	40657	2
Capacitor, 1.0 mfd 200v (C-235)	40714	1
Lamp, indicator (neon) I-202)	40854	1
Aperture, strip	40594	2
Capacitor, .25-.25 600v dual (C-231)	41237	1
Tube, electronic 2021W (V-212, 213)	70091-124	2

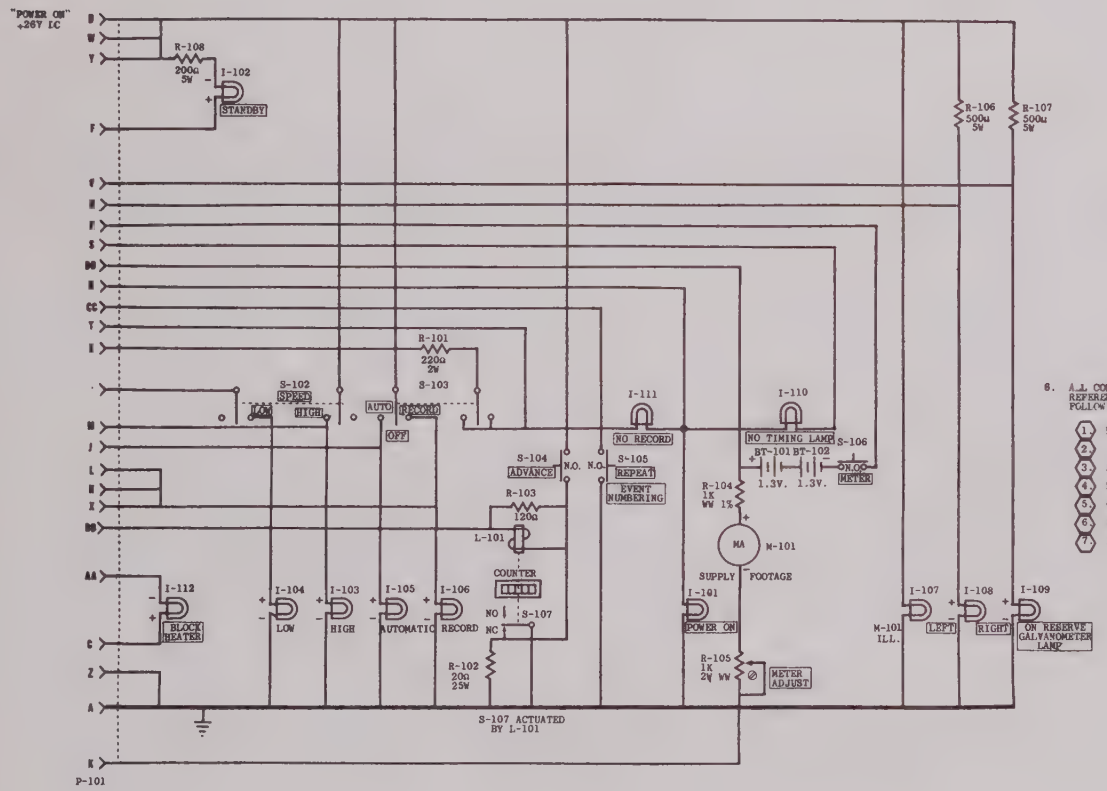
DESCRIPTION	PART NO.	NO. REQ'D.
Standoff #4-40 x 3/8	6889-24	2
Capacitor, .01 mfd 400v d-c 20% (C-227)	40646-4	1
Capacitor, .01 mfd 400v d-c 20% (C-230)	40646-4	1
Capacitor, .047 mfd 600v d-c 10% (C-229)	40650	1
Resistor, 12K 5 w 1% (R-273)	70026-1202	1
Resistor, 10 ohms 1 w 5% (R-290)	7139-1005	1
Rectifier, 1N589 (CR-210)	40893-2	1
Rectifier, 1N589 (CR-211)	40893-2	1
Resistor, 510K 1/2 w 5% (R-275)	7138-5145	1
Resistor, 510K 1/2 w 5% (R-276)	7138-5145	1
Resistor, 510K 1/2 w 5% (R-269)	7138-5145	1
Resistor, 10K 1/2 w 5% (R-272)	7138-1035	1
Resistor, 51K 2 w 5% (R-271)	7140-5135	1
Resistor, 51K 1/2 w 5% (R-270)	7138-5135	1
Resistor, 120K 1 w 5% (R-277)	7139-1245	1
Resistor, 10 ohms 1/2 w 5% (R-274)	7138-1035	1
Resistor, 270K 1/2 w 5% (R-281)	7138-2745	1
Resistor, 270K 1/2 w 5% (R-280)	7138-2745	1
Shield, lamp, indicator	49900	1
Resistor, 270K 1/2 w 5% (R-279)	7138-2745	1
Resistor, 4.7K 1/2 w 5% (R-282)	7138-4725	1
Resistor, 270K 2 w 5% (R-283)	7140-2745	1
Resistor, 2.4 meg 1/2 w 5% (R-286)	7138-2455	1
Resistor, 120 ohms 1/2 w 5% (R-292)	7138-1215	1
Bracket, slave unit	40997	1
Indicator Lamp Assembly, timing	40516	Ref.
Upper & Lower Panel Assembly	48047	1
End Panel, upper	49921	1
Angle, galv. block cover	29850	1
Hinge, block cover	29854	1
Clamp, loop type support	16786-3	2
Hinge, upper panel	30151	1
Shield	30156	1
Panel, connector, slave unit	48055	1
Receptacle	40665	2
Panel, upper	29848	1
Latch assembly	30149	1
Stud	30144	1
Latch, bar	30145	1
Plate, support	30071	1
Cover, galvanometer block	29860	1
Condensing Lens Assembly	40700	1
Lens, condensing (timing)	41012	1
Plate, aperture	40900	1
Mount, condensing lens (timing)	40668	1
Insulator, slave	49838	1
Plate, test button	41160	1
Switch, micro D.P.D.T.	39972-1	Ref.
Plate, type & serial no.	32174	1
Plug, coaxial	40664	2
Manual, instruction	34520-2113	1

DESCRIPTION	PART NO.	NO. REQ'D.
154930 INDICATOR LAMPS MODULE		
Indicator Lamps Module	154930	1
Indicator Lamp Assembly, timing	40516	1
Indicator Lamp Assembly	30737	1
Socket, bracket mounting	30753	2
Frame, indicator lamps	30526	1
Window, indicator lamps	40833	1
Window, indicator lamp	40834	1
Retainer, filter	30603	4
Mount, lamp socket	31981	1
Eyelet	21925	4
Shield	44252	1
Socket, miniature bayonet	40624	1
Socket, miniature, bayonet	40623	1
Lamp, NE51	19785-16	1
Window, indicator lamp	40979	1
Lamp - 356	19785-4	2
Switch, pushbutton D. P. D. T.	33875	1
5-006A MAGAZINE		
Base Assembly	154557	1
Bearing, flanged	31991	5
Belt, drive	37617	1
Ring, retaining	31388	1
Key, roller drive	30297	1
Pulley	29892	1
Gear, helical - 32-tooth	29836	1
Collar, Boston	19977	1
Drag Shaft Assembly	37342	1
Sector	31251	1
Pulley, adjusting	30141	1
Shaft, record follower	30086	1
Arm Paper Drag Casting	30091	1
Casting, arm	30091-0099	1
Pin Spring, .078 x 1/2	22628-0030	3
Pin Spring, .078 x 3/4	22628-0070	1
Pin Spring, .078 x 5/8	22628-0050	2
Gear, clash - 46-tooth	29838	2
Pin	25927	1
Ring, retaining, .250	21891-0007	3
Bearing, flanged	31353	1
Connector	31085	1
Roller, metering	29969	1
Bearing, ball	29783	1
Spacer, roller drive	30298	1
Retainer, bearing	33899	1
Cord Assembly, drag tension	30649-0001	1
Cord, nylon	18495	1
Sleeve	52091	2
Shaft, drag clutch	30087	1

DESCRIPTION	PART NO.	NO. REQ'D.
Gasket, gearing cover	42351	1
Cover, gearing	42344	1
Guide, spool shaft	30127	2
Plug, breather	42335	4
Plate, doubler	30534	1
Spring, shutter lock	30804	1
Shutter Actuator Assembly	30245	1
Actuator, shutter	30089	1
Stud	30238	1
Pin, pivot	30388	1
Shutter Assembly	30250	1
Shutter	30123	1
Guide, shutter	30240	1
Rivet, solid	30823	2
Plate, outer shutter	30173	1
Guide, paper	30092	1
Pin, spring	22628-0030	2
Plug, drag	29919	1
Gear, clash - 19-tooth	30120	1
Cover, window support fitting	42311	1
Gasket, fitting, window	42310	1
Ring, retaining	21891-006	1
Bearing, ball	29781	1
Window, support fitting	32146	1
Pin, drag - adjusting	30841	1
Shaft, magazine handle	30210	1
Handle, magazine carrying	30247	1
Ring, gear indexing	30511	1
Bearing, flanged	30536	2
Nut, bracket assembly	30215	1
Bracket	31250	1
Ind Cable Assembly	29922	1
Bracket, tension adjusting	31252	1
Spring, drag tension	30803	1
Commutator Brush Assembly	31176	1
Bracket, brush support	31170	1
Plate, clamping	31172	1
Insulator	31173	1
Brush, 1 7/8"	41464-0001	2
Brush, 2 1/4"	41464-0002	1
Guide	41465	1
Cord Assembly, drag tension	30649-0002	1
Cord, nylon	18495	As req'd.
Sleeve	52091	2
Stop, eccentric	32534	1
Spring, limiter	32560	1
Arm, casting	35789-0001	1
Arm, casting	30070-0001	1
Drag Spring Assembly	33734	1
Drag, spring	33736	1
Foot, rubber	30974	2
Arm, casting	35789-0002	1
Arm,	30070-0002	1

DESCRIPTION	PART NO.	NO. REQ'D.
Commutator Assembly, paper jam	36028	1
Pulley, drag	30118	1
Commutator, paper drag	30243	1
Input Shaft Assembly	36037	1
Bearing, retainer	30088	1
Shaft, input	30113	1
Spring, load	29800	1
Bearing, ball	29783	1
Spacer, input shaft	30541	1
Gear, helical - 23-tooth	29837	1
Pin, spring .078 x 1/2	22628-0030	1
Spacer	30119	1
Bearing, ball	29781	1
Takeup Clutch Assembly	36081	1
Shaft, clutch	30046	1
Flange, clutch	30045	1
Facing, clutch	30044	2
Ring and Pulley Assembly	30048	1
Pulley	29891	1
Ring, pulley	30049	2
Bearing, needle	31356	1
Flange, clutch	30043	1
Spring, magazine clutch	30660	1
Nut, clutch	30047	1
Pin	25927	1
Support Drum Assembly Fitting	48958	1
Pin, spring .078 x 1/2	22628-0030	1
Drum, supply, footage	31253	1
Band, supply, footage	32138	1
Potentiometer, 100 ohms 2 w	31254	1
Spring Fitting	31341	1
Spring, clock	31340	1
Bracket Assembly, potentiometer mtg.	35353	1
Bracket, potentiometer mtg.	31255	1
Pin, .087 x 1/4	35383	1
Standoff	51363	2
Base and Cover Assembly	155266	1
Magazine Casting	29829	1
Casting, magazine	29829-0099	1
Cover, magazine	42330	1
Cover, magazine - casting	42322	1
Lid Assembly	154621	1
Assembly and Printing, magazine	31558-0002	1
Retainer, spool	30117-0002	2
Retainer, spool	30117-0001	2
Knob	30315	2
Ring, retaining - ext 3/16	49933-0007	2
Spool Assembly	30597	1
Flange Assembly	33168	1
Retainer, spring	33162	1
Spacer	33163	4
Flange, paper roll	33164	1
Flange	33164-0099	1

DESCRIPTION	PART NO.	NO. REQ'D.
Spring, locking	33165	1
Spring	33165-0099	1
Shaft Assembly	30596	1
Pin, spring .078 x 1/2	22628-0030	2
Spindle	30587	1
Collar, shaft	30591	1
Collar, shaft	30592	1
Shaft, paper spool	30593	1
Bearing .0251 x .440 x.500	49952	2
Collar, flange	31257	1
Collar	31257-0099	1
Flange	30509	1
Collar, gear	30586	1
Gear, clash - 61-tooth	29839	1
Magazine Lid	29927	1
Handle, mounting casting	30053-0099	1
Plug, expansion	19642-0005	3
Plug, expansion	19642-0011	1
Plug, expansion	19642-0015	1
Tube	31557	1
Name Plate, magazine	154115	1



SYMBOL	DESCRIPTION	PART NO.
(1) BT-101	BATTERY "A" RM-12 1.3V	A-27644
(1) BT-102	BATTERY "A" RM-12 1.3V	A-27644
(2) I-101	LAMP 14V .10A	19785-2
(1) I-102	LAMP 14V .08A	A-37058
(1) I-103	LAMP .28V .04A	A-30748
(1) I-104	LAMP .28V .04A	A-30748
(1) I-105	LAMP .28V .04A	A-30748
(1) I-106	LAMP .28V .04A	A-30748
(1) I-107	LAMP, 28V .04A	A-30748
(1) I-108	LAMP .28V .04A	A-30748
(1) I-109	LAMP .28V .04A	A-30748
(2) I-110	LAMP 14V .10A	19785-2
(2) I-111	LAMP 14V .10A	19785-2
(1) I-112	LAMP 14V .08A	A-37058
(7) J-101	PLUG, MIN.	A-30777
(5) L-101	SOLENOID, ROTARY	A-30438
(1) M-101	METER, 0-1 MA	B-33133
(1) R-101	RESISTOR 220Ω 2W±10%	7140-2211
(1) R-102	RESISTOR 20Ω 25 W	70017-2003
(4) R-103	RESISTOR 120Ω 1/2 W	7138-1211
(4) R-104	RESISTOR 1K 1W W.W.±1%	A-8111
(3) R-105	RHEOSTAT 1K 2W W.W.	A-30581
(2) R-106	RESISTOR 500Ω 5W	22466-17
(2) R-107	RESISTOR 500Ω 5W	22466-17
(3) R-108	RESISTOR 200Ω 5W	22466-12
(1) S-102	SWITCH, TOGGLE D.P.D.T.	A-30770
(1) S-103	SWITCH, TOGGLE D.P.D.T.	A-22461
(1) S-104	SWITCH	A-30720
(1) S-105	SWITCH	A-30720
(1) S-106	SWITCH	A-30720
(8) S-107	SWITCH, S.P.D.T.	70087-7

6. A.L. COMPONENTS MARKED ⬡ ARE LISTED FOR REFERENCE ONLY AND MAY BE FOUND ON THE FOLLOWING ASSYS., AS INDEXED.

(1) REMOTE CONTROL ASS'Y. D-30681.
(2) INDICATOR LAMP ASS'Y. B-30755.
(3) POTENTIOMETER MTG. BRACKET ASS'Y. B-30791.
(4) BATTERY MOUNTING ASS'Y. A-30782.
(5) COUNTER ASS'Y. B-30747.
(6) SOLENOID SWITCH ACTUATING ASS'Y. B-34463.
(7) PUSH BUTTON BRACKET ASS'Y. B-30786.

5. SYMBOL ⏚ INDICATES CIRCUIT GROUND.
4. BOXED CONTROL TITLES INDICATE CONTROL PANEL LOCATION.
3. SYMBOL ⊘ ON POTENTIOMETERS INDICATES SCREWDRIVER ADJUSTMENT.
2. UNLESS OTHERWISE SPECIFIED, ALL RESISTORS ARE IN OHMS ±10%.
1. ALL VALUES SHOWN ADJACENT TO COMPONENTS, ON FACE OF DRAWING, ARE FOR REFERENCE ONLY.

NOTES:

D-30705 sht 5

CONSOLIDATED ELECTRODYNAMICS CORPORATION, PASADENA CALIFORNIA

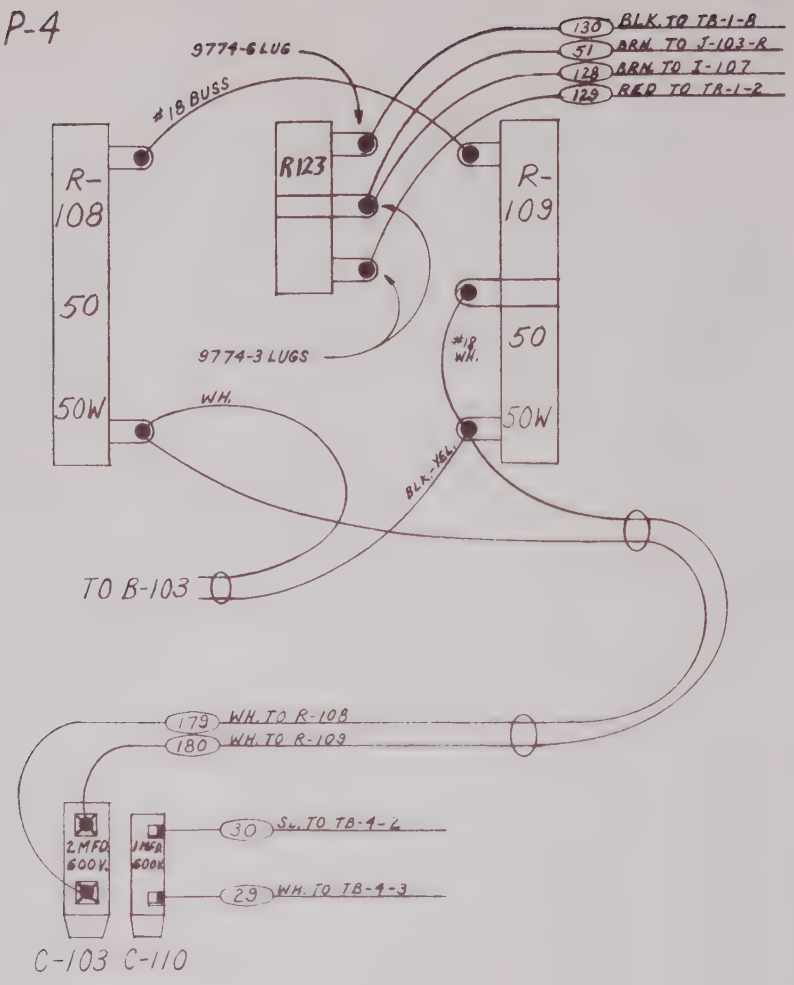
5-119 RECORDING OSCILLOGRAPH

11-108 REMOTE CONTROL SCHEMATIC

LOT 15 | 30705 S (REF)

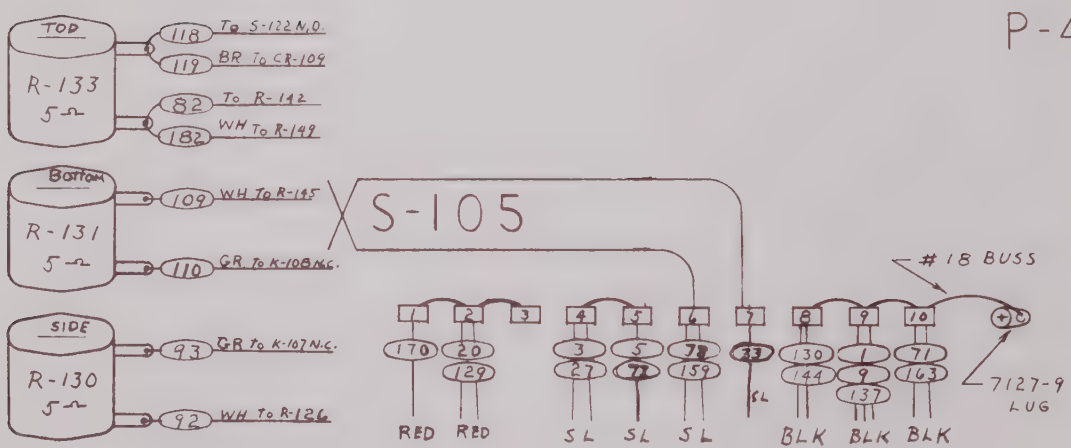
Symbol	Page
B-102	23
B-103	1 - 11
B-104	24
C-103	1
C-104	5
C-105	5
C-106	9
C-107	5
C-108	5
C-109	9
C-110	1
C-112	3
C-113	3
CR-101	8
CR-103	25
CR-104	25
CR-105	25
CR-106	10
CR-107	10
CR-108	10
CR-109	10
CR-110	5
CR-111	10
CR-112	10
CR-113	10
CR-114	25
CR-115	24
CR-116	24
CR-118	25
E-102	24
F-101	13
F-102	13
F-103	13
F-104	13
F-105	13
F-106	13
I-101	18
I-102	14
I-103	14
I-104	14
I-105	14
I-106	23
I-107	18
I-108	18
I-109	18
I-110	17
J-101	21
J-102	24
J-103	22
J-104	21
J-201	21
K-101	7
K-102	7
K-103	11
K-104	8
K-105	8
K-106	6
K-107	15
K-108	15
K-109	11
L-101	25
L-102	25
L-104	25
L-105	24
L-106	24
M-101	17 - 23
R-103	3
R-104	19
R-105	19
R-106	19 - 20
R-107	19 - 20
R-108	1
R-109	1
R-110	5
R-111	5
R-112	5
R-113	5
R-119	3
R-120	3
R-123	1 - 2
R-124	16
R-125	16
R-126	9
R-127	9
R-130	2
R-131	2
R-132	16
R-133	2
R-138	9
R-139	16
R-142	9
R-143	17
R-144	16
R-145	9
R-146	9
R-147	9
R-149	9
R-152	24
R-154	3
R-155	3
S-101	17
S-102	20
S-103	20
S-104	19 - 20
S-105	2
S-106	17
S-107	25
S-108	25
S-111	17
S-112	16
S-113	16
S-114	16
S-115	16
S-120	17
S-121	16
S-122	16
S-124	17
S-125	16
S-128	24
S-129	24
S-130	24
T-101	4
TB-1	2
TB-2	12 - 19 - 20
TB-3	23 - 25
TB-4	3
TB-5	24

P-4



1

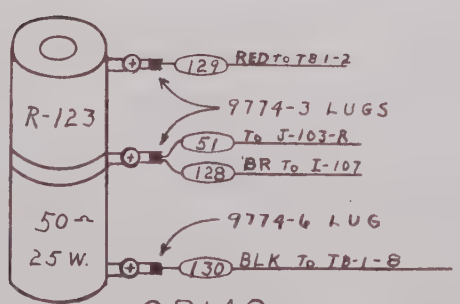
P-4



TB-NO. 1-OP. 130

170-TO TB-3-8
20-TO S-101
129-TO R-123
3-TO F-101
27-TO K-101 N.C.
5-TO T-101-1
33-TO TB-4-1
78-TO R-103
159-TO TB-2-2
130-TO R-123
1-TO J-103 A, 2
9-TO T-101-6
71-TO R-144
163-TO R-112
144 TO J-201-C-BUSS
137 TO K-103-W.
77 TO TB-4-2

SCH. 29466-CC



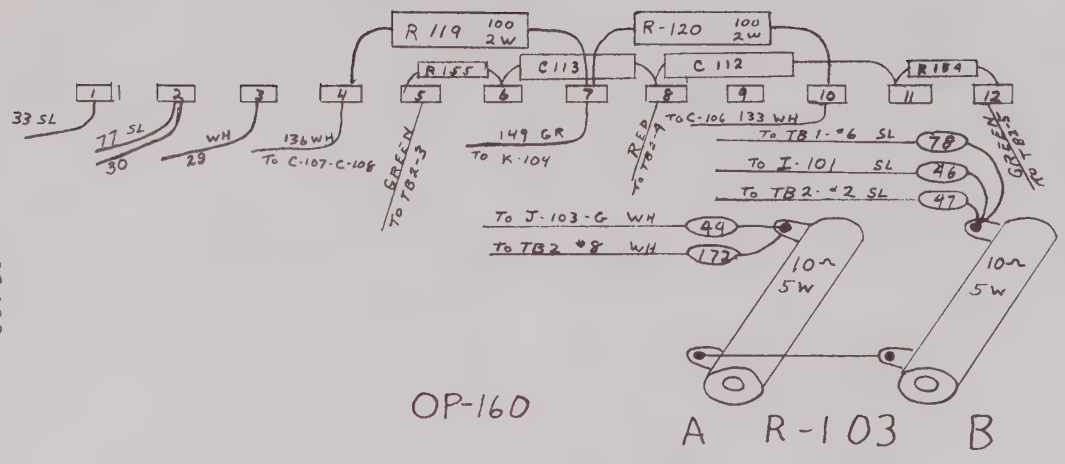
OP. 140

P-4

5-119

P-4

TB-4



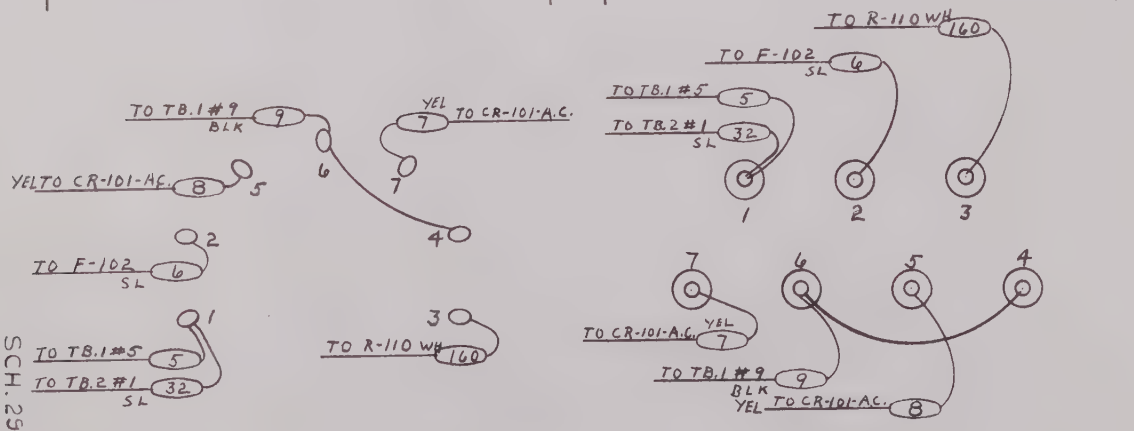
SCH. 29466-

3

W P-4 5-119

P-4 T-101 P-4

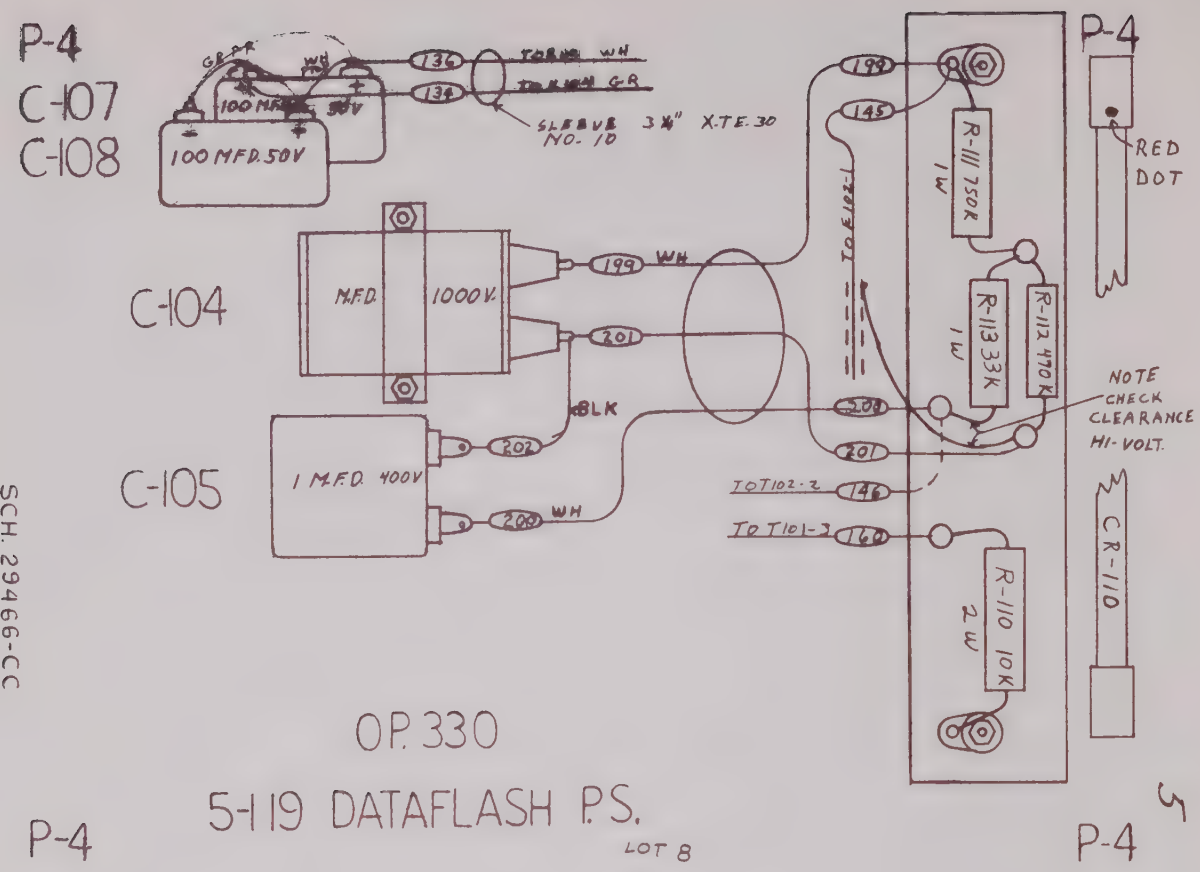
T.E. TRIAD

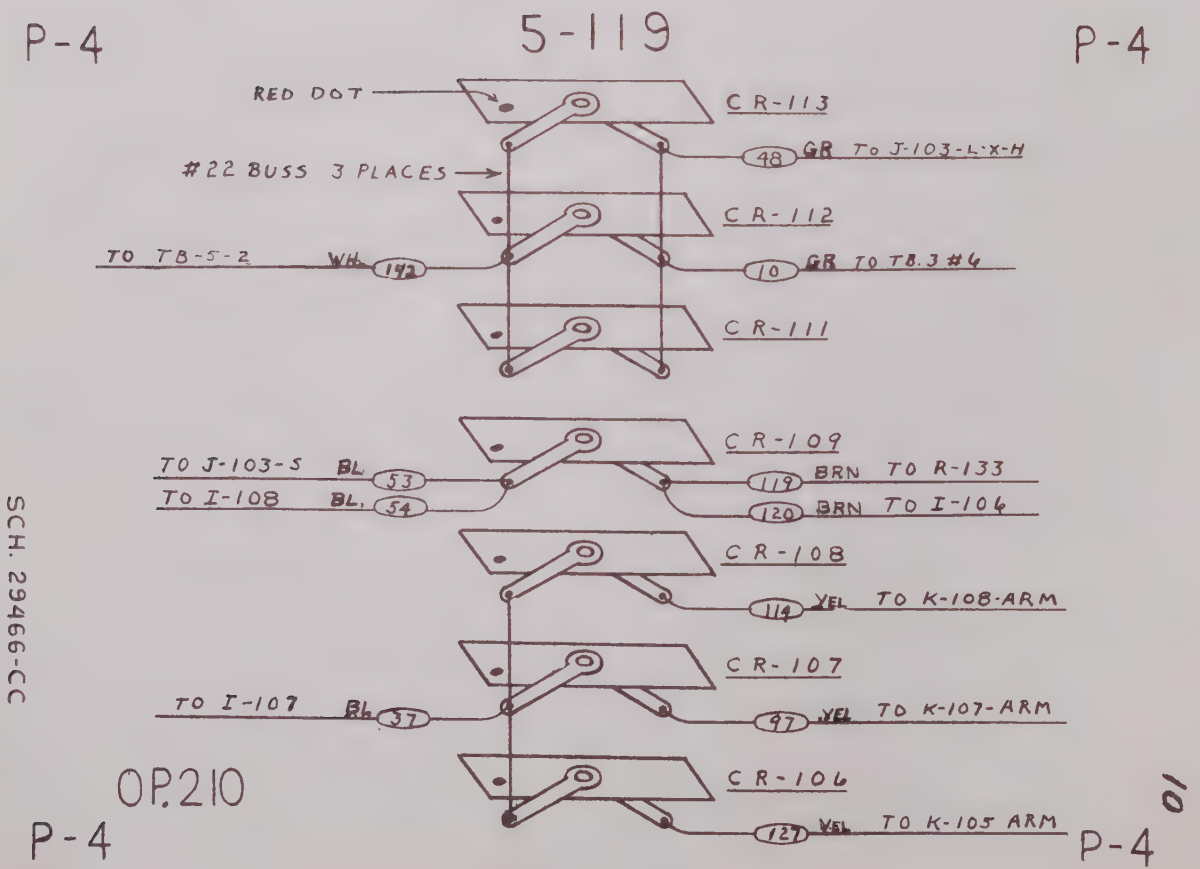

TO TB.1 #9 BLK 9
YEL TO CR-101-A.C. 7
YEL TO CR-101-AC. 8
TO F-102 SL 6
TO TB.1 #5 5
TO TB.2 #1 SL 32
TO R-110 WH 160
TO R-110 WH 160
TO F-102 SL 6
TO TB.1 #5 5
TO TB.2 #1 SL 32
TO CR-101-A.C. YEL 7
TO TB.1 #9 BLK 9
YEL TO CR-101-AC. 8

SCH. 29466-CC

4

P-4 5-119 P-4


P-4
C-107
C-108
100 MFD. 50V
SLEEVE NO. 10 3¾" X.T.E. 30
C-104
M.F.D. 1000V.
C-105
1 M.F.D. 400V
BLK
WH
TO E102-1
R-111 750R 1W
R-113 33K 1W
R-112 470K
NOTE CHECK CLEARANCE HI-VOLT.
RED DOT
CR-110
TO T102-2
TO T101-2
R-110 10K 2W
P-4
P-4
OP. 330
5-119 DATAFLASH P.S.
LOT 8
P-4
P-4
SCH. 29466-CC
5

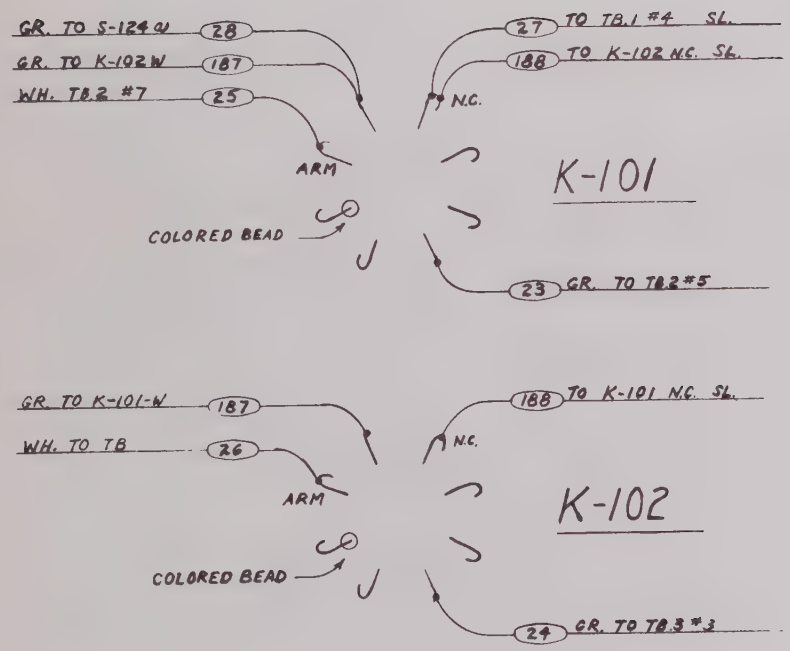

P-4
5-119
P-4
RED DOT
#22 BUSS 3 PLACES
CR-113
48 GR TO J-103-L-X-H
CR-112
TO TB-5-2 WH 192
10 GR TO TB.3 #4
CR-111
CR-109
TO J-103-S BL 53
TO I-108 BL 54
119 BRN TO R-133
120 BRN TO I-104
CR-108
114 YEL TO K-108-ARM
CR-107
TO I-107 BL 37
97 YEL TO K-107-ARM
CR-106
127 YEL TO K-105 ARM
OP. 210
P-4
P-4
SCH. 29466-CC
10

P-4

7

P-4

5-119
OP. 180



P-4

SCH. 29466

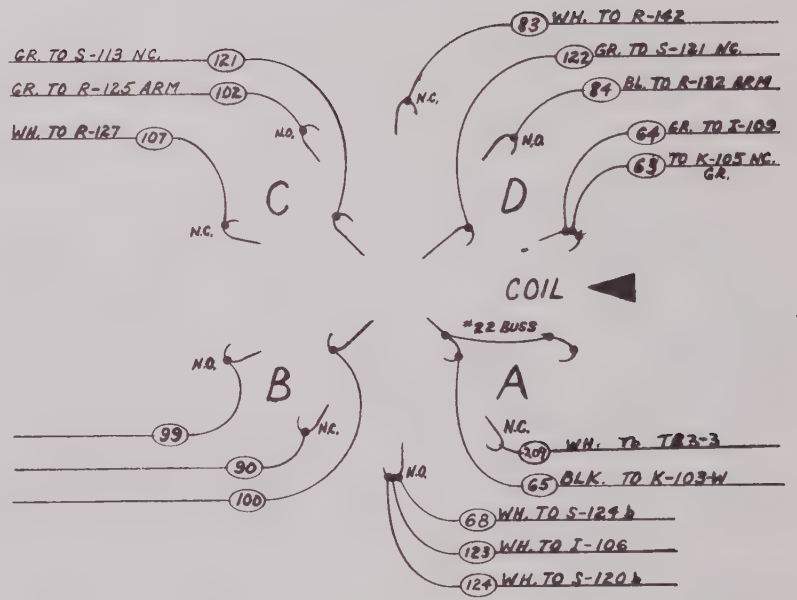
P-4

P-4

6

P-4

K-106
OP.-170



P-4

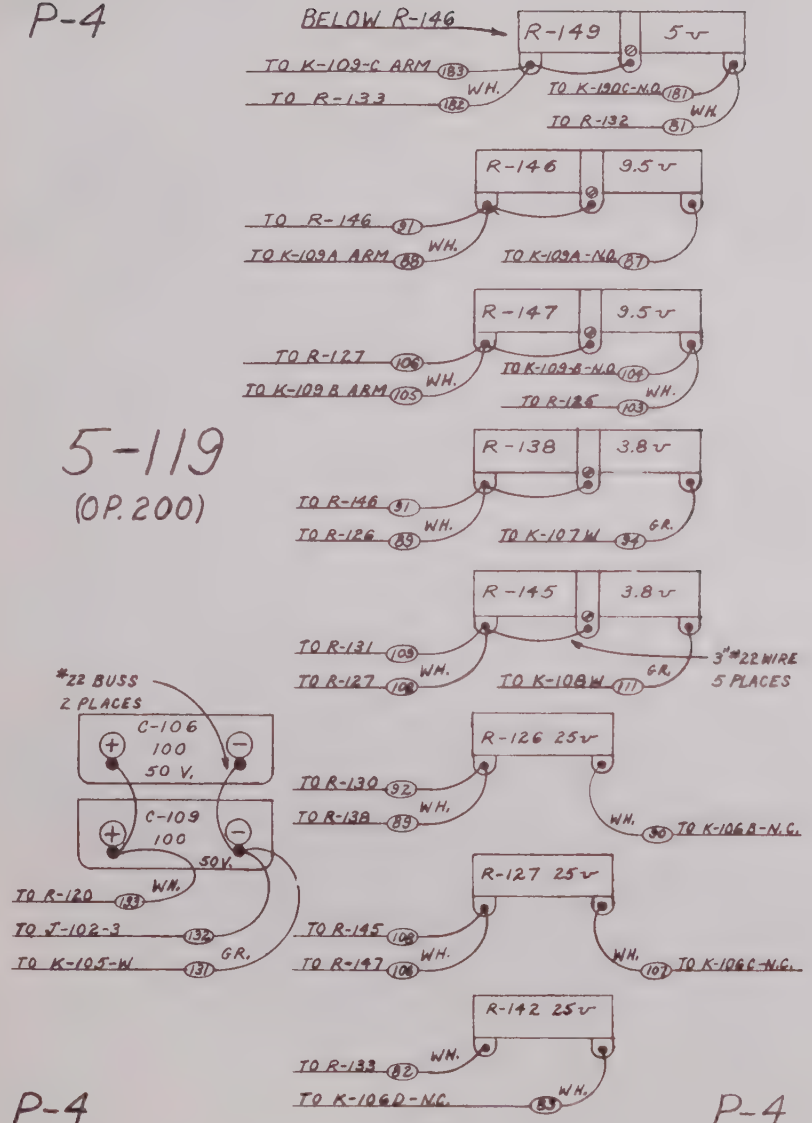
5-119

P-4

SCH. 29466

P-4

P-4

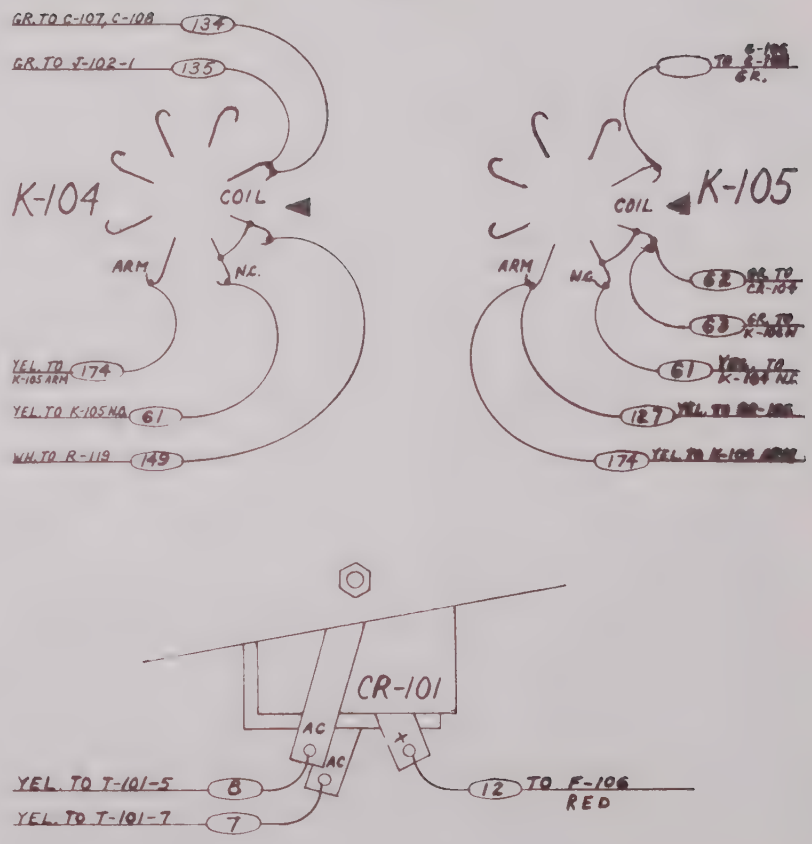


P-4

SCH. 29466-CC

P-4

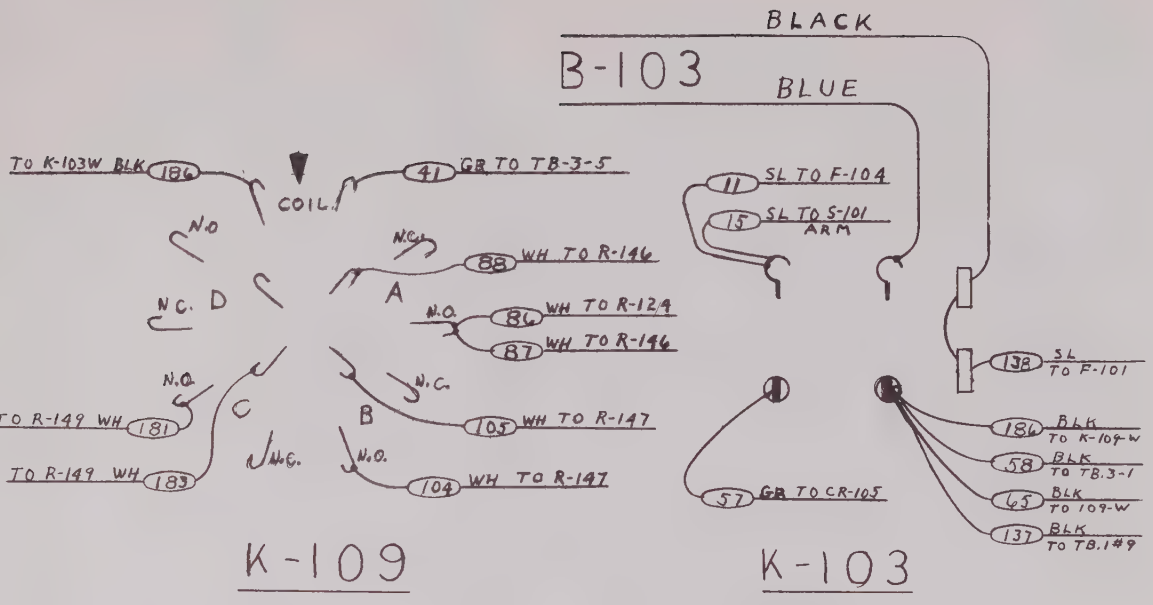
5-119
OP. 190



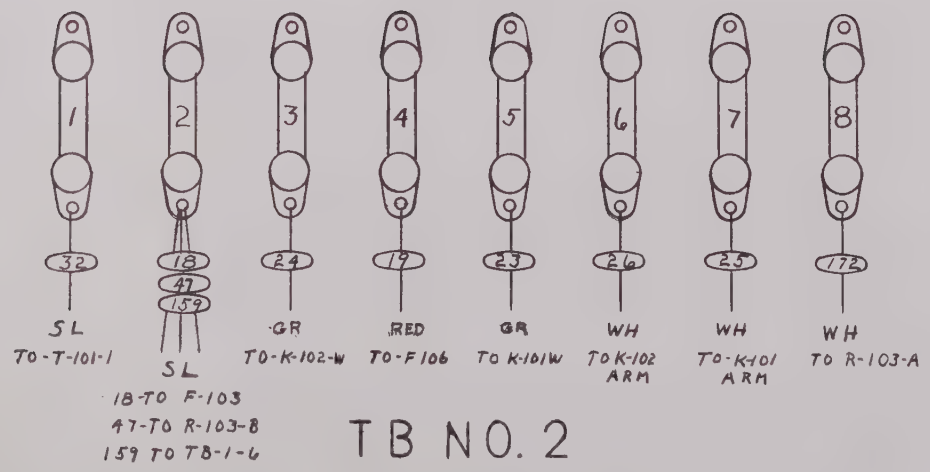
P-4

SCH. 29466-CC

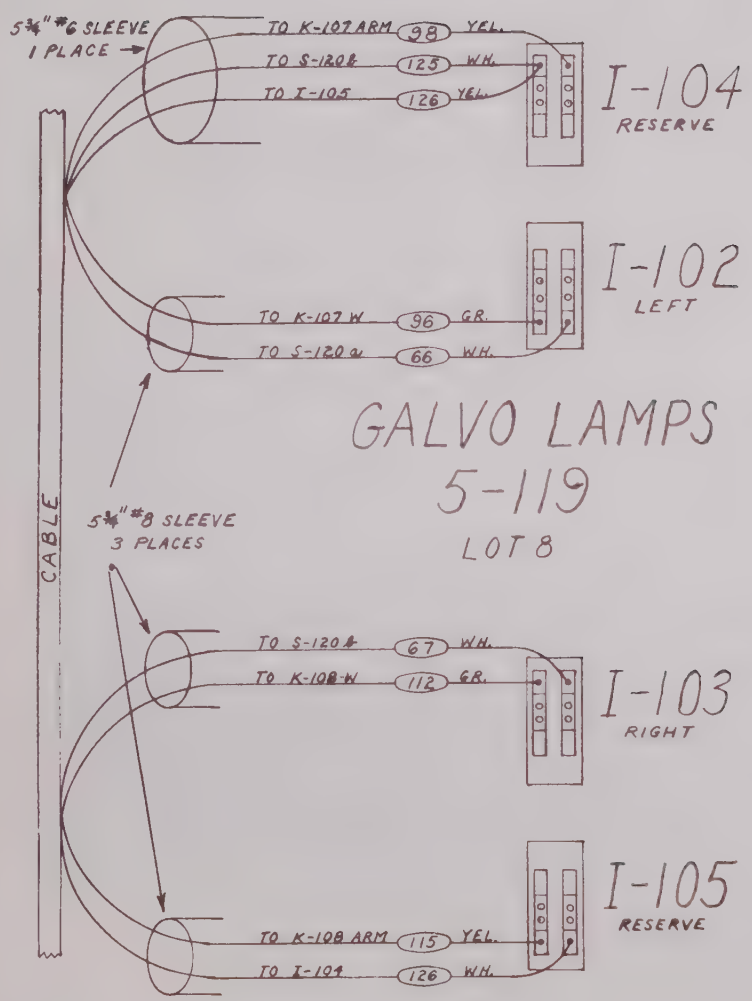
P-4



SCH. 29466



SCH. 29466



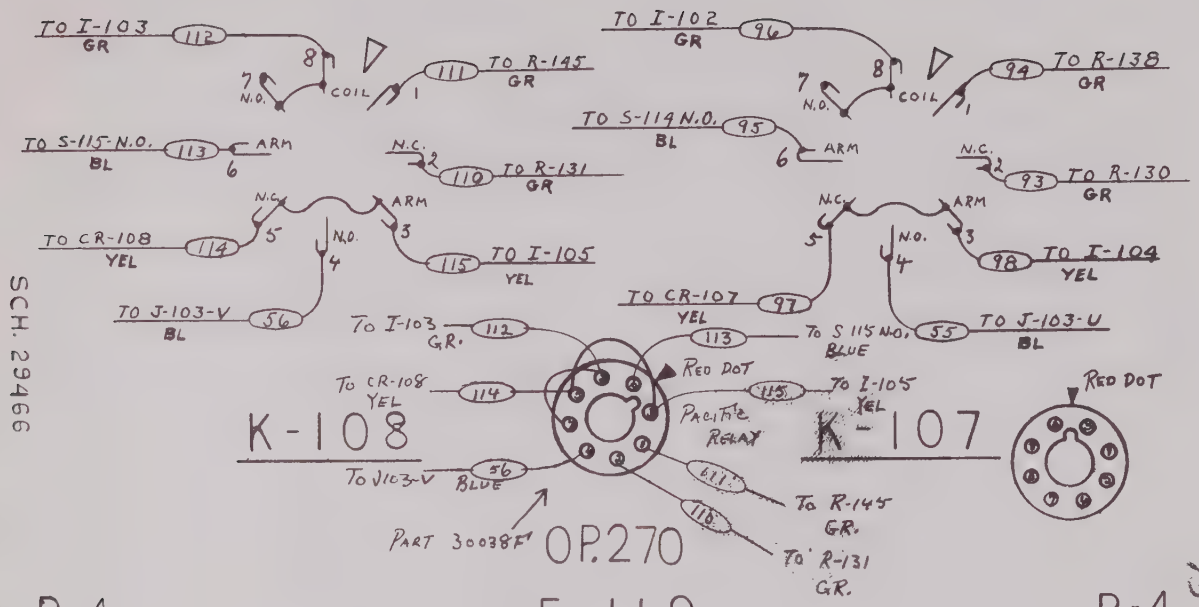
P-4 SCH. 29466-CC P-4

FUSE PANEL

P-4 5-119 P-4

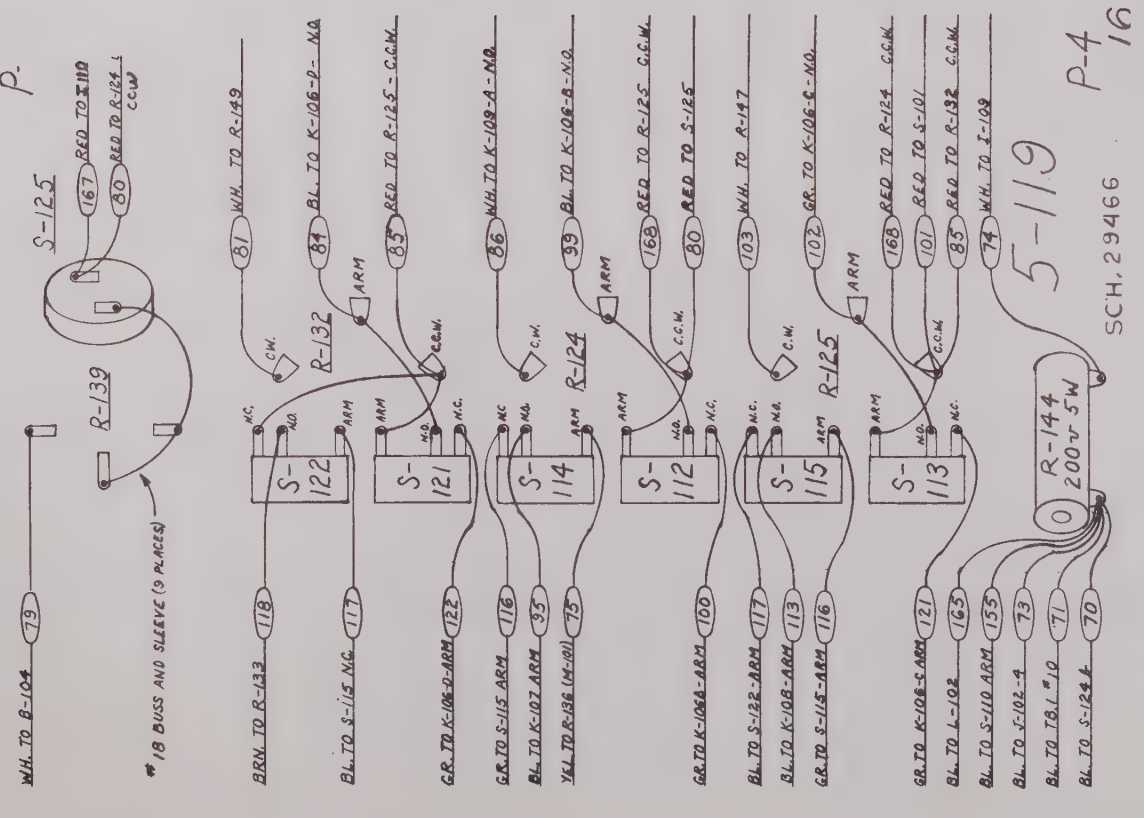
SCH. 29466-CC

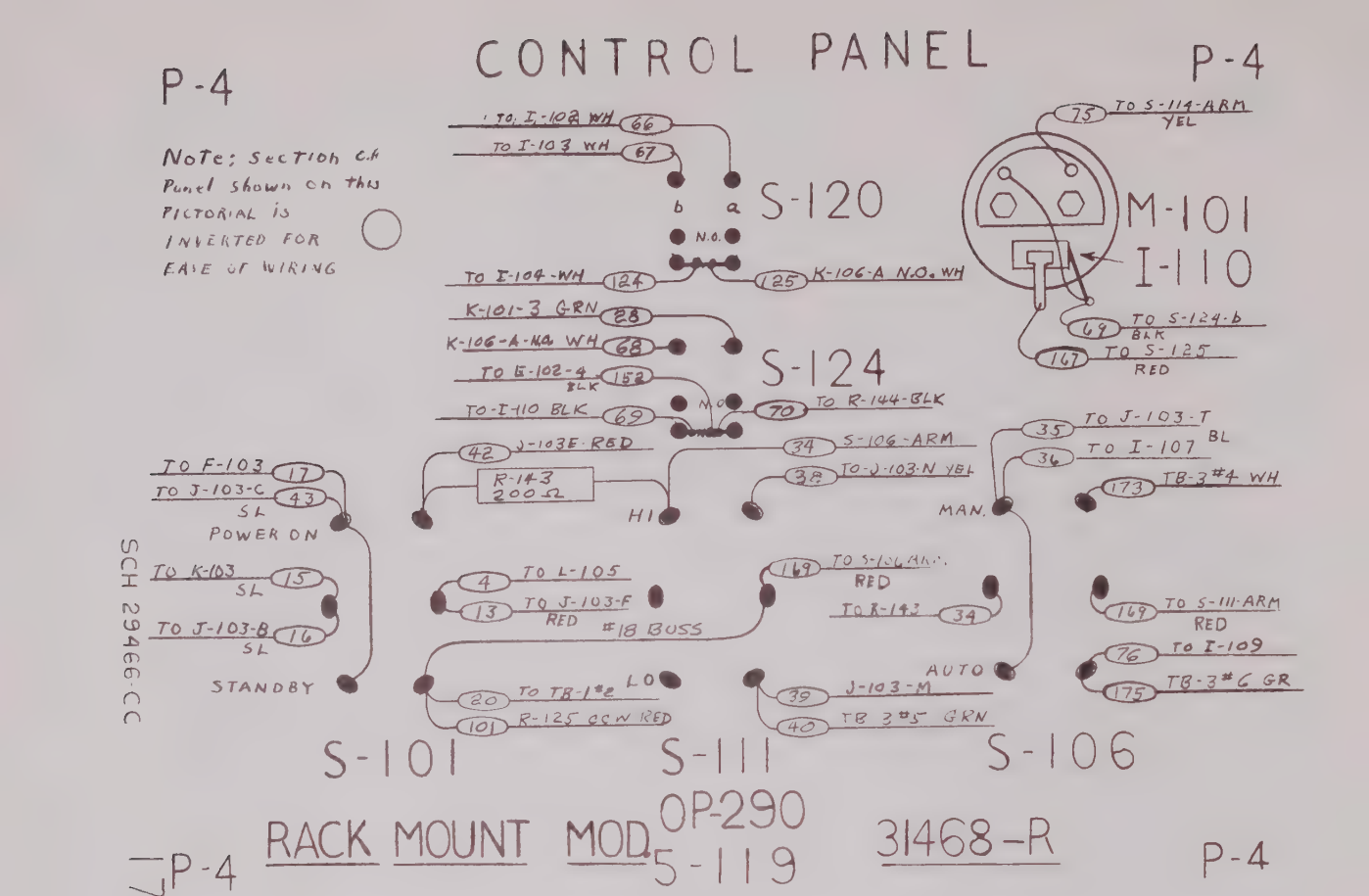
P-4


TO I-103 GR
112
TO I-102 GR
96
TO R-145 GR
111
TO R-138 GR
94
TO S-114 N.O. BL
95
TO S-115 N.O. BL
113
ARM
6
TO R-131 GR
110
TO R-130 GR
93
TO CR-108 YEL
114
TO I-105 YEL
115
TO I-104 YEL
98
TO CR-107 YEL
97
TO J-103-V BL
56
TO J-103-U BL
55
TO S 115 N.O. BLUE
RED DOT
PACITRE RELAY
K-108
K-107
TO R-145 GR.
TO R-131 GR.
PART 30038F1
OP.270
5-119
SCH. 29466

P-4

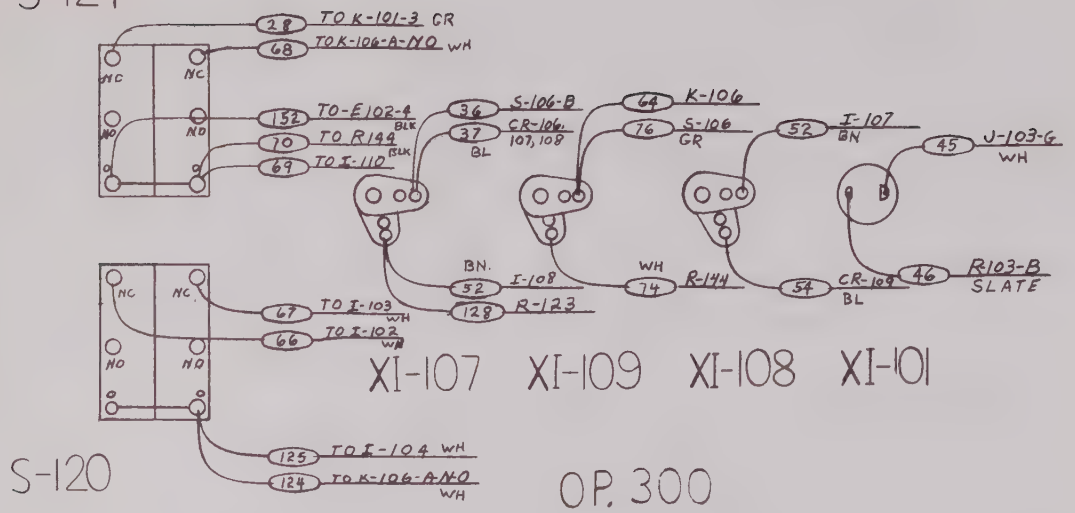
P-4


CONE-TROL ASSY.
S-125
R-139
WH. TO B-104
79
#18 BUSS AND SLEEVE (9 PLACES)
167
RED TO X110
80
RED TO R-124 CCW
R-132
R-124
R-125
S-122
S-121
S-114
S-112
S-115
S-113
R-144 200Ω 5W
81
WH. TO R-149
84
BL. TO K-106-P-NO
85
RED TO R-125 C.C.W.
86
WH. TO K-108-A-NO
99
BL. TO K-106-B-NO
168
RED TO R-125 C.C.W.
80
RED TO S-125
103
WH. TO R-147
102
GR. TO K-106-C-NO
168
RED TO R-124 C.C.W.
101
RED TO S-101
85
RED TO R-132 C.C.W.
74
WH. TO I-109
BRN. TO R-133
118
BL. TO S-115 NC
117
GR. TO K-108-D-ARM
122
GR. TO S-115 ARM
116
BL. TO K-107 ARM
35
YEL. TO R-138 (M-101)
75
GR. TO K-108A-ARM
100
BL. TO S-122-ARM
117
BL. TO K-108-ARM
113
GR. TO S-115-ARM
116
GR. TO K-108-S ARM
121
BL. TO L-102
165
BL. TO S-110 ARM
135
BL. TO X-102-4
73
BL. TO TB1 #10
71
BL. TO S-124-L
70
5-119
SCH. 29466
P-4
16


CONTROL PANEL
P-4
P-4
NOTE; SECTION OF PANEL SHOWN ON THIS PICTORIAL IS INVERTED FOR EASE OF WIRING
TO I-102 WH 66
TO I-103 WH 67
S-120
b a
N.O.
TO I-104-WH 124
125 K-106-A N.O. WH
K-101-3 GRN 28
K-106-A-NC WH 68
S-124
TO E-102-4 BLK 152
TO I-110 BLK 69
N.O.
70 TO R-144-BLK
42 J-103E-RED
R-143 200Ω
HI
34 S-106-ARM
38 TO J-103-N YEL
75 TO S-114-ARM YEL
M-101
I-110
69 TO S-124-b BLK
167 TO S-125 RED
35 TO J-103-T BL
36 TO I-107
173 TB-3 #4 WH
MAN.
TO F-103 17
TO J-103-C 43 SL
POWER ON
TO K-103 15 SL
TO J-103-B 16 SL
STANDBY
4 TO L-105
13 TO J-103-F RED #18 BUSS
169 TO S-106 ARM. RED
TO R-142 34
20 TO TB-1 #2 LO
101 R-125 CCW RED
39 J-103-M
40 TB 3 #5 GRN
AUTO
169 TO S-111-ARM RED
76 TO I-109
175 TB-3 #6 GR
SCH 29466-CC
S-101
S-111
S-106
OP-290
5-119
RACK MOUNT MOD.
31468-R
P-4
P-4
P-4

CONTROL PANEL
P-4
P-4
NOTE; SECTION OF PANEL SHOWN ON THIS PICTORIAL IS INVERTED FOR EASE OF WIRING
TO K-106-A-N.O. WH 124
TO I-104 WH 125
S-120
b a
TO I-103 WH 67
N.O.
N.C.
66 TO I-102 WH
TO I-110 BLK 69
TO R-144 BLK 70
TO E-102-4 BLK 152
S-124
TO K-106-A-N.O WH 68
28 TO K-101-3 GR
207 TO J-102-7 RED
20 TO TB.1 #2
101 TO R-125 C.C.W RED
HI
39 TO J-103-M
40 TO TB.3 #5 GR
#18 BUSS
4 TO L-105
13 TO J-103-F RED
169 TO S-106 ARM. RED
TO R-143 34
R-143 200
34 TO S-106 ARM.
42 TO J-103-E RED
LO
38 TO J-103-N YEL
MAN.
AUTO
5 TO S-114-ARM YEL
M-101
I-110
69 TO S-124-b BLK
167 TO S-125 RED
35 TO J-103-T BL
36 TO I-107
76 TO I-109 GR
175 TO TB.3 #6
208 J-102-8 GR
169 TO S-111-ARM RED
173 TO TB.3 #4 WH
TO F-103 17
TO J-103-C 43 SL
POWER ON
TO K-103 15 SL
TO J-103-B 16 SL
STANDBY
SCH. 29466-CC
S-101
S-111
S-106
OP.290
5-119
P-4
P-4
P-4
17A

S-124



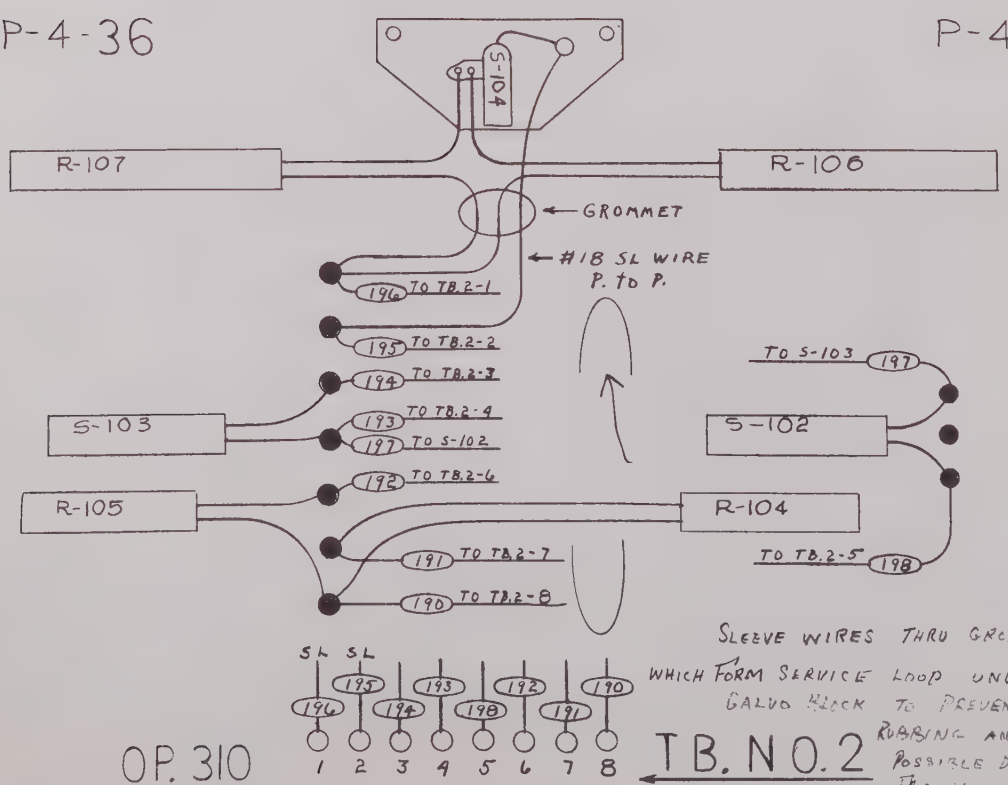
SCH. 29466

S-120

OP. 300

P-4 5-119 P-4

P-4-36 P-4-36

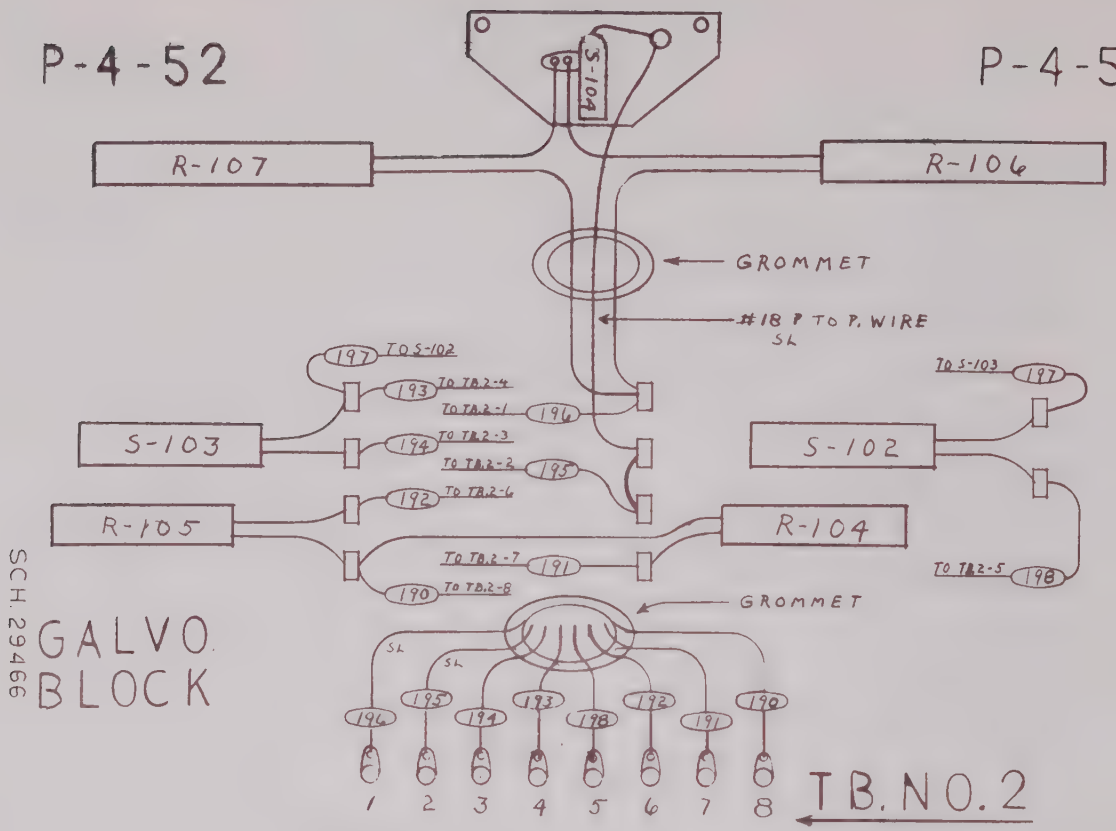


SCH. 29466

SLEEVE WIRES THRU GROMMET WHICH FORM SERVICE LOOP UNDER GALVO BLOCK TO PREVENT RUBBING AND POSSIBLE DAMAGE FROM [illegible]

OP. 310

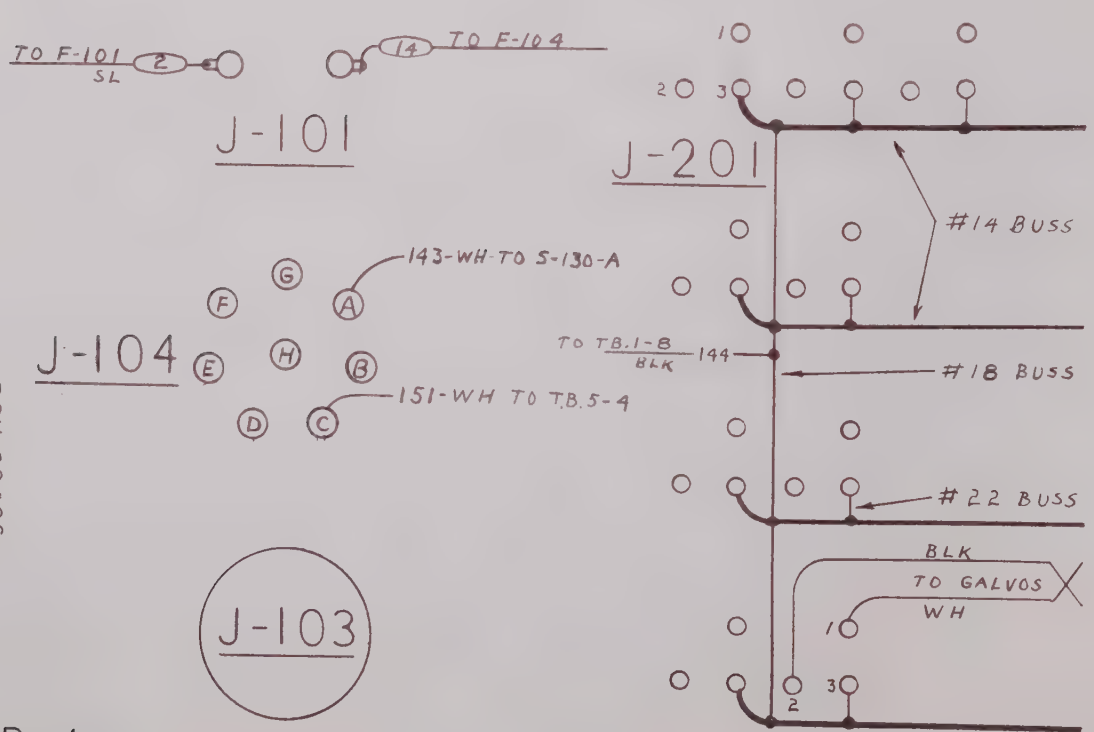
P-4-36 5-119 GALO. BLOCK P-4-36



SCH. 29466

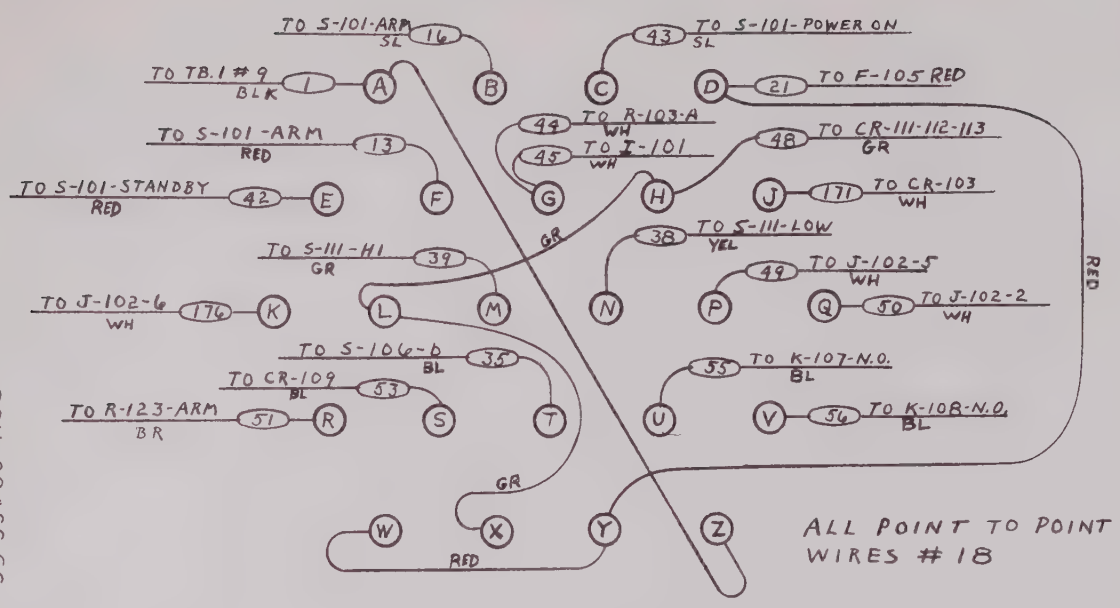
GALVO BLOCK

GALVO INPUT PANEL



SCH. 29466

P-4 J-103 P-4

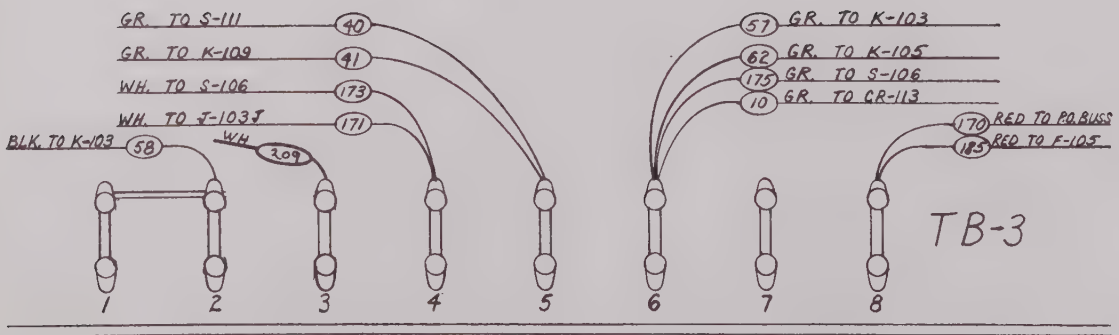

TO S-101-ARM SL 16
TO TB.1 #9 BLK 1
TO S-101-ARM RED 13
TO S-101-STANDBY RED 42
TO S-111-HI GR 39
TO J-102-6 WH 176
TO S-106-b BL 35
TO CR-109 BL 53
TO R-123-ARM BR 51
43 TO S-101-POWER ON SL
21 TO F-105 RED
44 TO R-103-A WH
45 TO I-101 WH
48 TO CR-111-112-113 GR
171 TO CR-103 WH
38 TO S-111-LOW YEL
49 TO J-102-5 WH
50 TO J-102-2 WH
55 TO K-107-N.O. BL
56 TO K-108-N.O. BL
GR
RED
A B C D E F G H J K L M N P Q R S T U V W X Y Z
ALL POINT TO POINT WIRES #18

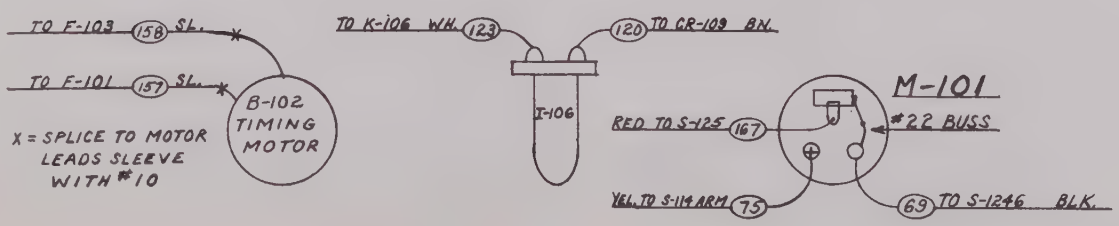
SCH. 29466-CC

J-103

22 P-4 OP.10 5-119 P-4

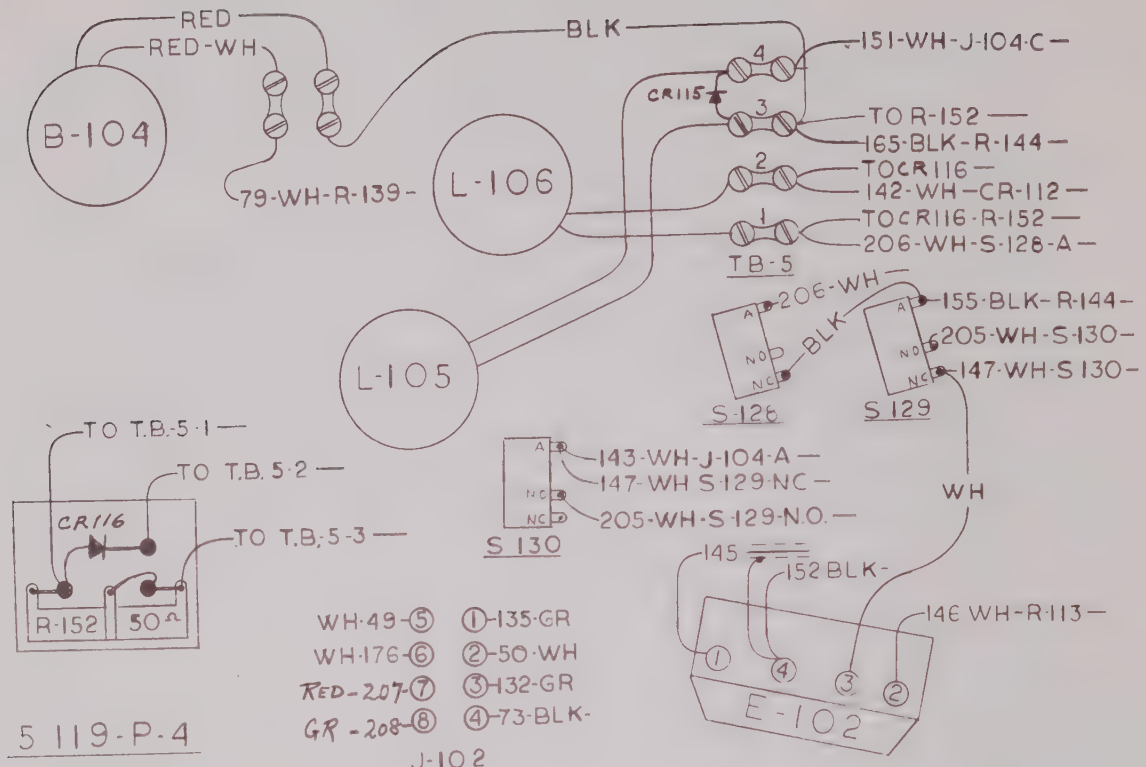
5-119-P-4





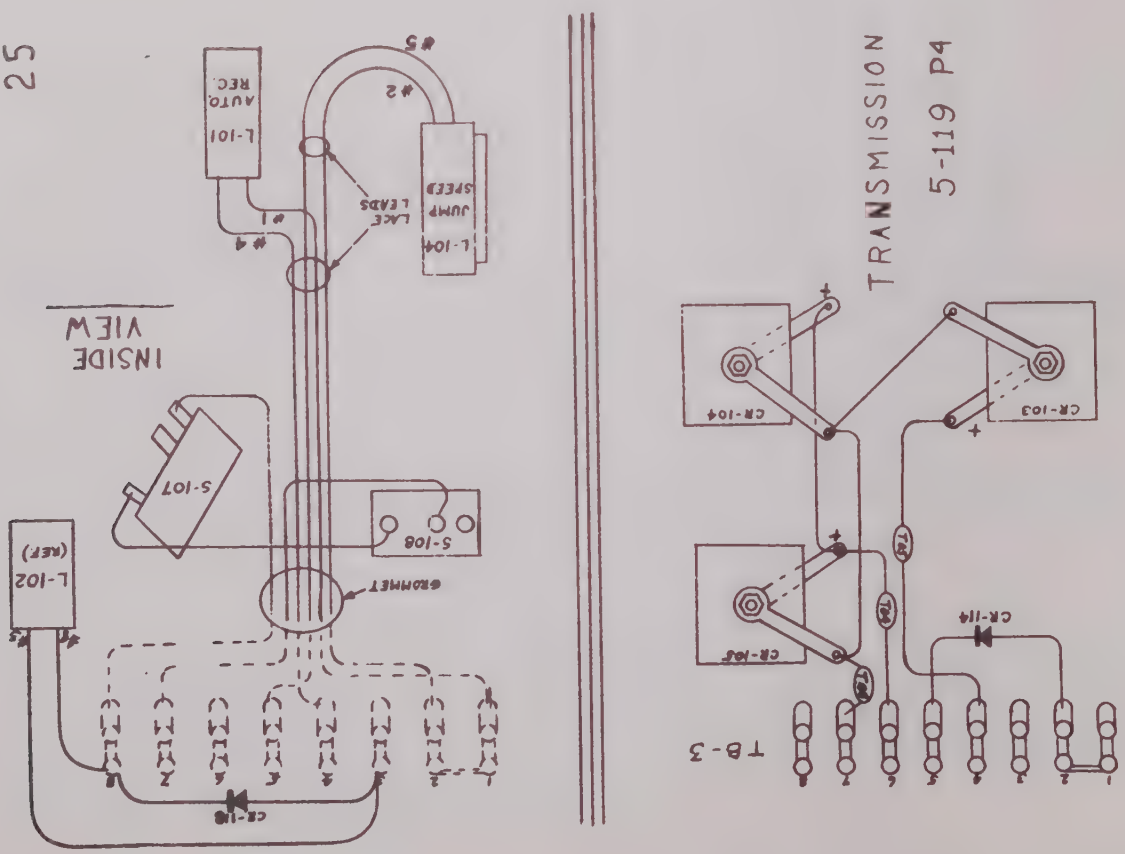
SCH. 29466-CC

23

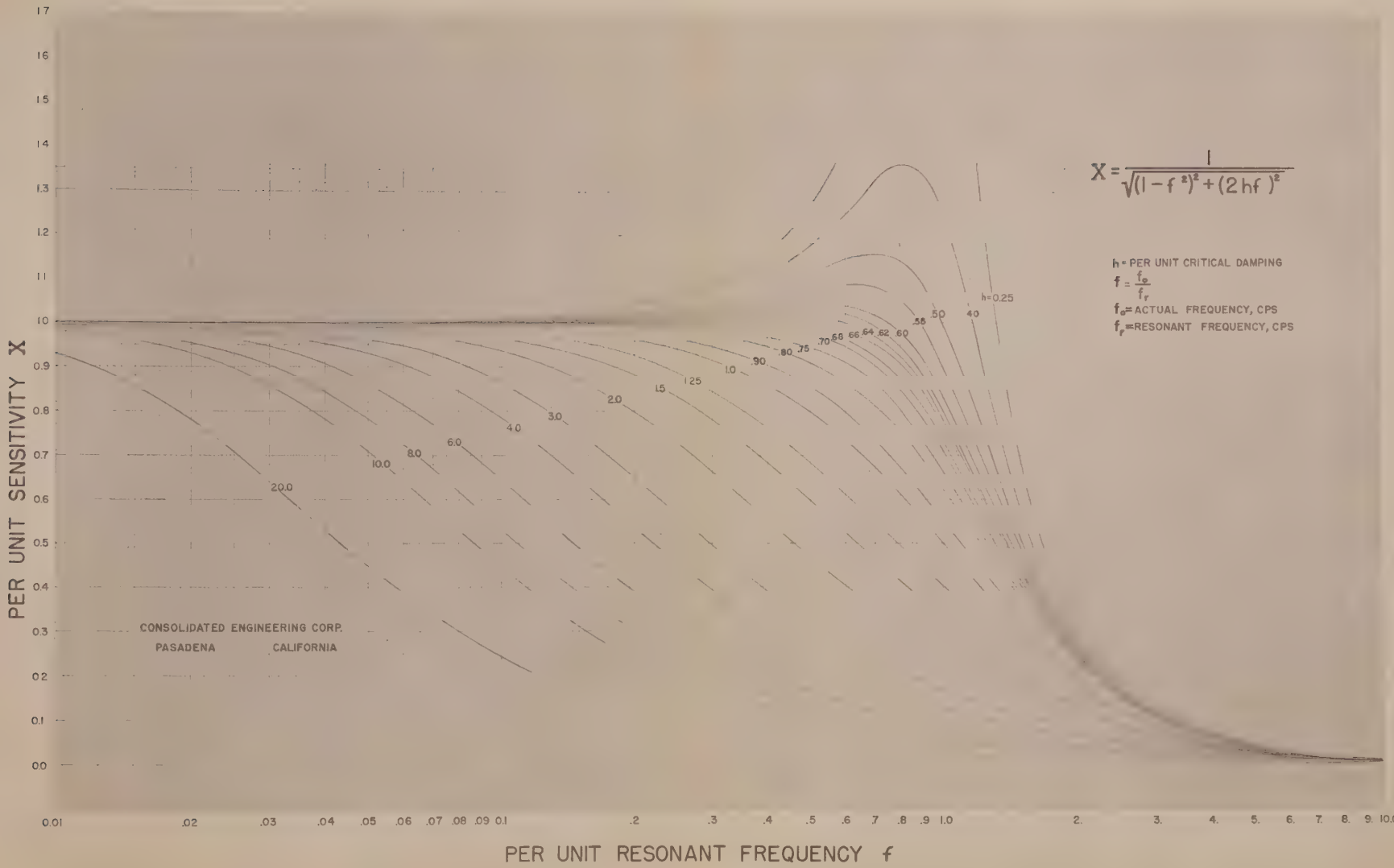

RED
RED-WH
B-104
79-WH-R-139-
L-106
BLK
151-WH-J-104-C
CR115
TO R-152
165-BLK-R-144
TO CR116
142-WH-CR-112
TO CR116-R-152
206-WH-S-128-A
TB-5
L-105
206-WH
BLK
155-BLK-R-144
205-WH-S-130
147-WH-S 130
S-128
S 129
TO T.B.-5-1
TO T.B. 5-2
TO T.B.-5-3
CR116
R-152
50Ω
143-WH-J-104-A
147-WH S-129-NC
205-WH-S-129-N.O.
S 130
WH
145
152 BLK-
146 WH-R-113
E-102
WH-49-⑤
WH-176-⑥
RED-207-⑦
GR-208-⑧
①-135-GR
②-50-WH
③-132-GR
④-73-BLK-
J-102
5 119-P-4
SCH. 29466-

24

52


INSIDE VIEW
L-101 AUTO. REC.
#2
#5
#4
#1
LACE LEADS
JUMP SPEED
L-104
S-107
S-108
GROMMET
L-102 (REF)
CR-108
TRANSMISSION
5-119 P4
CR-104
CR-103
CR-107
CR-114
TB-3

GALVANOMETER FREQUENCY-RESPONSE CHARACTERISTICS



SYM.	DESCRIPTION	PART NO.
B-101	MOTOR, BLOWER	39086
B-102	MOTOR, TIMING	28969
B-103	MOTOR, RECORD DRIVE	29126
B-104	MOTOR, SCAN	29803
C-103	CAP., .2 MFD, 600 W. V.	9553-23
C-104	CAP., FINED DIELECTRIC	154354
C-105	CAP., 1 MFD, 400 W. V.	35066
C-106	CAP., 100 MFD, 50 W. V.	29200
C-107	CAP., 100 MFD, 50 W. V.	29200
C-108	CAP., 100 MFD, 50 W. V.	29200
C-109	CAP., 100 MFD, 50 W. V.	29200
C-110	CAP., 1 MFD, 330 W. V. A-C	39109
C-112	CAP., 0.1 MFD, 200 V	70020-1042
C-113	CAP., 0.1 MFD, 200 V	70020-1042
CR-101	RECT.	36744
CR-103	RECT.	29824
CR-105	RECT.	29824
CR-106	RECT.	29824
CR-107	RECT.	29824
CR-108	RECT.	29824
CR-109	RECT	29824

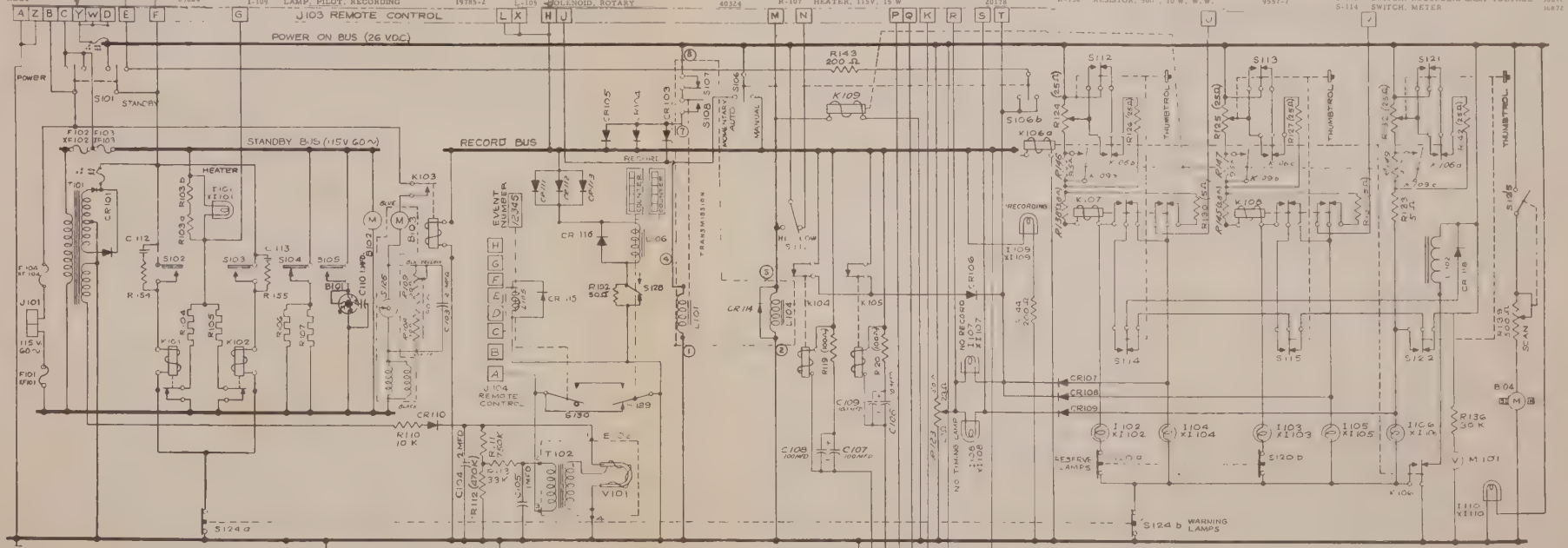
SYM.	DESCRIPTION	PART NO.
	CR-110 RECT.	29104
	CR-111 RECT.	29824
	CR-112 RECT.	29824
	CR-113 RECT.	29824
	CR-114	
	CR-115 RECT. IN93	33744-3
	CR-116	
	CR-118 RECT. IN93	33744-3
E-101	COMMUTATOR, JAM.	30243
E-102	FLASH TUBE	29300
F-101	FUSE, 10 AMP, SLO BLOW	16656-35
F-102	FUSE, 2 AMP, SLO BLOW	16656-32
F-103	FUSE, 3 AMP, SLO BLOW	16656-33
F-104	FUSE, 10 AMP, SLO BLOW	16656-35
I-101	LAMP, PILOT	19785-5
I-102	LAMP, RECORD, MAIN NO. 1	21642
I-103	LAMP, RECORD, MAIN NO. 2	21642
I-104	LAMP, RECORD, RESERVE	21642
I-105	LAMP, RECORD, RESERVE	21642
I-106	LAMP, TIMING	21642
I-107	LAMP, PILOT, NO RECORD	19785-2
I-108	LAMP, PILOT NO TIMING LAMP	19785-2
I-109	LAMP, PILOT, RECORDING	19785-2

SYM.	DESCRIPTION	PART NO.
I-110	LAMP, PILOT METER ILLUM.	30748
F-105	FUSE, 3 AMP, SLO BLOW	16656-33
F-106	FUSE, 10 AMP, SLO BLOW	16656-35
J-101	RECEPTACLE, POWER	30290
J-102	RECEPTACLE, MAG.	31084
J-103	RECEPTACLE, REMOTE CONTROL	38024-4
J-104	RECEPTACLE, REMOTE CONTROL	38008-4
J-201	RECEPTACLE, GALV. (36)	18290 (50)
J-236		
K-101	RELAY, BLOCK HEATER	33890
K-102	RELAY, BLOCK HEATER	33890
K-103	RELAY, DRIVE MOTOR	29121
K-104	NO RECORD	29120
K-105	NO RECORD	29120
K-106	RECORD	29202
K-107	RELAY, REC. LAMP LEFT	30038
K-108	RELAY, REC. LAMP RIGHT	30038
K-109	RELAY	29404
L-101	SOLENOID, AUTO RECORD LENGTH	29106
L-102	SOLENOID, ROTARY (BRAKE)	43668
L-104	SOLENOID, JUMP SPEED	37101
L-105	SOLENOID, ROTARY	40324

SYM.	DESCRIPTION	PART NO.
L-106	SOLENOID, ROTARY	40326
M-101	METER, VOLT	36327
M-201 thru M-236	GALVANOMETER, REF. ONLY (36)	GEC TYPE 7-200 SERIES
M-201 thru M-252	GALVANOMETER, REF. ONLY (50)	GEC TYPE 7-400 SERIES
M-261	DYNAMIC REF. TRACE (36)	35755
P-102	CONNECTOR	31085
P-201A thru P-236A	GALVANOMETER CLIP (36)	32467
P-201A thru P-252A	GALVANOMETER CLIP (50)	32467
P-261A	GALVANOMETER CLIP (36)	32467
R-103a	RESISTOR, 10Ω 5 W	22466-4
R-103b	RESISTOR, 10Ω 5W	22466-4
R-104	HEATER, 115V 46 W (50)	29600
R-104 R-105	HEATER, 115V 35 W (36)	29369
R-106	HEATER 115V 15 W	20178
R-107	HEATER, 115V, 15 W	20178

SYM.	DESCRIPTION	PART NO.
R-108	RESISTOR, 50Ω 50 W	29099
R-109	RESISTOR, 50Ω, 50 W	29099
R-110	RESISTOR, 10K 2W	7140-1035
R-111	RESISTOR, 750K, 1 W	7139-7545
R-112	RESISTOR, 470K, 1/2 W	7138-4741
R-113	RESISTOR, 33K, 1 W	7139-3321
R-119	RESISTOR, 100Ω 2 W	7140-1011
R-120	RESISTOR, 100Ω 2 W	7140-1011
R-121	POTENTIOMETER 100	31254
R-123	RESISTOR, 10Ω, 25 W	14296-9
R-124	POTENTIOMETER, 25Ω , 25 W	31304
R-125	POTENTIOMETER, 25Ω , 25 W	31304
R-126	RESISTOR, 25Ω , 5 W	22466-28
R-127	RESISTOR, 25Ω , 5 W	22466-28
R-130	RESISTOR, 5Ω , 10 W	22465-23
R-131	RESISTOR, 5Ω , 10 W	22465-23
R-133	RESISTOR, 5Ω , 10 W	22465-23
R-149	RESISTOR, 7.5Ω , 10 W	9612-5
R-136	RESISTOR, 30K SPOOL	PART OF M-101
R-152	RESISTOR, 50Ω , 10 W, W.W.	9557-7

SYM.	DESCRIPTION	PART NO.
R-138	RESISTOR, 3.6Ω , 10 W	9612-4
R-139	POT W/SWITCH, 500Ω	31305
R-142	RESISTOR, 25Ω , 5 W	22466-28
R-143	RESISTOR, 200Ω , 2 W	7140-2015
R-144	RESISTOR, 200Ω , 5 W	22466-12
R-145	RESISTOR, 3.8Ω , 10 W	9612--
R-146	RESISTOR, 9.5Ω , 10 W	9612-6
R-147	RESISTOR, 9.5Ω , 10 W	9612-6
R-154	RESISTOR, 10Ω 1/2 W	7138-1005
R-155	RESISTOR, 10Ω 1/2 W	7138-1005
S-101	SWITCH, POWER	22460
S-102	THERMOSTAT, HEATER	19016
S-103	THERMOSTAT, HEATER	19016
S-104	THERMOSTAT, HEATER	28459
S-105	THERMOSTAT, BLOWER	29819
S-106	SWITCH, RECORD	22461
S-	S	
S-108	SWITCH, AUTO REC. LENGTH	36872
S-111	SWITCH, JUMP SPEED	30770
S-112	SWITCH, RECORDING LAMP VOLTAGE	36871
S-113	SWITCH, RECORDING LAMP VOLTAGE	36871
S-114	SWITCH, METER	36872



PART X

ACCESSORIES

A. TYPE 11-108 REMOTE CONTROL (Fig. 10:01)

Permits operation of the recording oscillograph from a distance of 25 feet when used with the standard length cable. The embodied indicators and controls are:

1. POWER ON Panel Light

   Indicates the position of the power switch on the oscillograph.

2. STANDBY - Jewel Indicator

   On if the oscillograph power switch is set to STANDBY.

3. SPEED - Two-Position Toggle Switch

   HIGH and LOW positions verified by indicator lights. The main oscillograph SPEED switch must be on LOW before the remote switch will act as the master control.

4. RECORD - Three-Position Toggle Switch

   MANUAL and AUTOMATIC positions are verified by indicator jewels. OFF position is verified by unlighted jewels. The main oscillograph RECORD switch must be off.

5. RESERVE GALVANOMETER LAMP - Two Indicator Jewels

   LEFT and RIGHT. A lighted jewel shows that the corresponding main galvanometer lamp is inoperative and that the reserve lamp is in use.

6. NO RECORD - Red Panel Light

   Indicates recording medium stoppage, or burnout of either left or right main and reserve recording lamps. If the warning is due to reserve lamp failure, its indicator jewel will still be on, but the red NO RECORD indicator will come on also.

7. NO TIMING LAMP - Red Panel Light

   Indicates burnout of the timing lamp.

8. BLOCK HEATERS - Yellow Jewel Light

   On when the magnet block heaters are on.

9. REPEAT And ADVANCE - EVENT NUMBERING - Pushbuttons (S-105 and S-104)

   EVENT NUMBER counter can be controlled by the 11-108 or external circuitry provided by the user. As a consequence, the RECORD NUMBER counter in the oscillograph is no longer controlled by the 11-108 ADVANCE and REPEAT buttons as in previous 5-119 lots. The oscillograph RECORD NUMBER counter sequentially numbers the record and not events. Event numbering is as follows:

TYPE 11-108 REMOTE CONTROL
FIG. 10:01

5-119P4
6-59 2061

a. During REMOTE recording operation, depressing the 11-108 ADVANCE button will advance and print the EVENT NUMBER counter in the oscillograph and will advance the 11-108 RECORD NUMBER counter. Depressing the REPEAT button will print the existing number of the EVENT NUMBER counter on the record as many times as desired, at a maximum rate of 1 flash per second with no change in any counter.

b. When no recording is taking place, depressing the ADVANCE button will only advance the EVENT NUMBER counter in the oscillograph and advance the RECORD NUMBER counter in the 11-108. Depressing the REPEAT button has no effect on the counter circuitry.

c. Automatic record numbering due to record starting and stopping will function normally just as it does without the use of the 11-108.

10. METER - Pushbutton

Actuates the percent of record remaining meter.

11. RECORD REMAINING - Meter

Indicates the percentage of unused paper or film. The reading should agree approximately with the reading on the record magazine. In case of material difference, reset as follows:

a. Install empty record magazine, cover removed, on the oscillograph.

b. Push in the follower arm that bears against the supply reel core, until the magazine footage indicator reads one-half.

c. Turn the adjusting screw on the end of the remote control unit until its meter reads one-half.

d. The meter is actuated by a dry cell inside the remote control which may need replacement occasionally.

12. RECORD NUMBER - Counter

a. The count increases one unit each time the ADVANCE EVENT NUMBERING button is depressed.

b. The count does not advance automatically each time the record is started with the record switch.

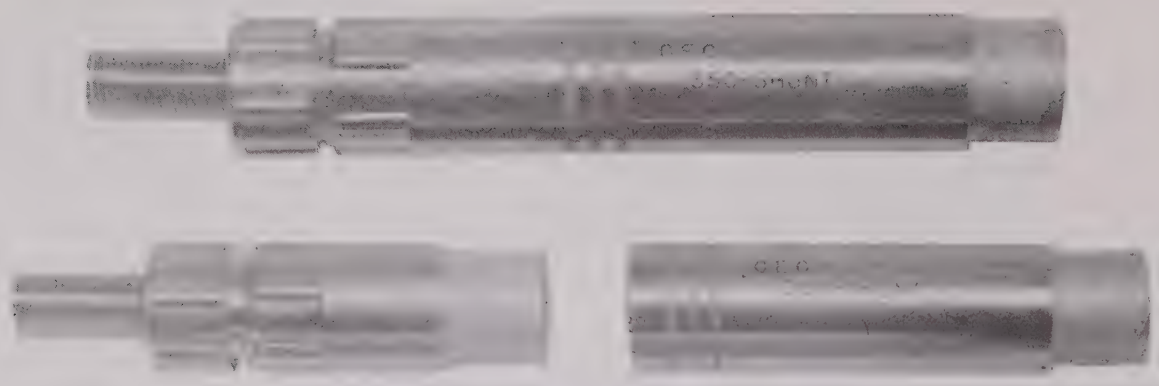
c. The oscillograph EVENT COUNTER advances each time the remote control counter advances.

d. The count may be set to zero by turning the adjusting screw at the right end of the unit.

13. The remote control unit cover may be removed by loosening the knurled screw above the record remaining meter.

B. PLUG-IN DAMPING RESISTORS (Fig. 10:02)

These resistors mate with the galvanometer-input receptacle on the oscillograph and the galvanometer-input connector. They are used in those cases where galvanometers are driven by a source whose impedance does not provide proper damping resistance. CEC Part No. 49541 provides a shunt resistor. Part No. 49542 provides a series resistor. Part No. 21987 provides a "T" pad or " π" resistors. Details of the use and the calculation of resistance values are given in Part III, Galvanometers, Section C.



TYPICAL SHUNT PLUG-IN DAMPING RESISTOR
PART NO. 49541
FIG. 10:02

TYPE 23-109 A OSCILLOGRAM PROCESSOR
FIG. 10:03

C. MEASUREMENT - RECORDING SYSTEMS

Fig. 10:05 contains a brief description of standard CEC systems for measurement and recording of static and dynamic data. Except in the case of direct recording, the application of which is quite limited, some system of amplification or balance is necessary as a link between transducer and galvanometer. Complete data regarding the instruments outlined may be obtained by writing for the applicable bulletin, listed in the last column of the table.

D. TRANSDUCERS

Consolidated Transducers are available for measurement of pressure and linear or torsional vibration. Complete specifications are located in the Appendix section of this manual.

E. OSCILLOGRAM PROCESSOR, TYPE 23-109A

Record processing at the test site with speed and ease is made possible by use of the CEC Type 23-109A Oscillogram Processor. The developed oscillogram can be ready for study by engineering personnel in less than an hour after completion of a test run. Processing speeds are approximately five to ten feet per minute, depending on exposure density, ambient humidity, and record width. The operator can inspect the oscillogram as it issues from the solution tanks in continuous process, and adjust the speed for optimum results. The drive motor speed is continuously adjustable (Fig. 10:03).

The unit is portable and may be operated in daylight, or used to simplify darkroom procedure. Power from a 115- or 230-volt, 60-cycle a-c connection is required. The drying drum is electrically heated, and the solutions are thermostatically maintained at 100°F, to insure uniformity of results under varying ambient conditions.

Personnel with no previous photographic laboratory experience can process oscillograms competently and with ease, for loading and processing techniques have been highly simplified. Solutions are contained in individually removable tanks, so that a single tank may be replenished or refilled without disturbing the others. The latest chemical processes developed by Eastman and DuPont are utilized. The record passes through developer, stop bath, and two tanks containing a stabilizer solution. No washing is needed and no water connection is required for processing.

Transfer of the record roll from the oscillograph magazine to the processor magazine may be accomplished in subdued light or a darkroom, depending on the recording material used.

Dimensions: length 30 1/2 inches, width 16 3/4 inches, height 17 7/16 inches. Weight 140 pounds, dry. More complete information is given in CEC Bulletin 1537, sent on request.

Consolidated offers developer, stop bath, and stabilizer, packaged in kits. The contents of one kit supply one charge for the processor. The kit of DuPont chemicals is carried as CEC part number 35131; the Eastman kit may be ordered as CEC part number 33099.

F. DUMMY GALVANOMETER, Cat. No. 7-003 (Fig. 10:04)

The description and use of dummy galvanometers are covered in Part III.

G. STATIC GALVANOMETER REFERENCE TRACE, Cat. No. 7-002 (Fig. 10:04)

When more fixed reference traces than those provided with each oscillograph are needed, they may be conveniently added at any point in the magnet block and adjusted to any position on the record. Having standard pole pieces, these static galvanometer reference traces also serve to maintain uniform flux and the characteristics of adjacent active galvanometers.

TYPE 7-300
GALVANOMETER

STATIC
REFERENCE TRACE

DYNAMIC REFERENCE
TRACE

DUMMY
GALVANOMETER

5-119P4
6-59 2061

FIG. 10:04

H. DYNAMIC REFERENCE TRACE, Cat. No. 7-004 (Fig. 10:04)

When a timing mark, on-off indication, or waveform of known value is to be recorded along with other data, the dynamic reference trace can be employed. This is installed in the 36-trace oscillograph only, attached to the left end of the left galvanometer block. Standard electrical connections, and lateral but not vertical mirror adjustment are provided. The signal input plug is marked DYNAMIC and is on the rear deck adjacent to the number 33 galvanometer input.

This unit is lower in sensitivity than the regular galvanometers, as shown in CEC Bulletin No. 2102, Part III, Galvanometers; therefore, not suitable for recording precise test data.

I. VERTICAL RACK MOUNTING, Cat. No. 5-017 (Fig. 2:03)

The 5-119P4 Recording Oscillograph may be conveniently rack-mounted at permanent installations at a considerable saving in space, and with the advantage of permanent wiring. The shockmount supports are included. This mount may be obtained from CEC on special order. Note that an oscillograph for rack mounting is special order also, in that all the control panel and identification lettering are inverted. This does not preclude use of the same instrument in field service at slight inconvenience in operation.

The oscillograph tips forward far enough to permit easy attachment and removal of the magazine. A removable cover encloses the galvanometer input plugs, and conceals the leads, which are usually brought from the cabinet interior. In the rackmount configuration, the 5-036 DATARITE Magazine cannot be used.

The blower screen and inspection panels on the sides of the instrument are readily accessible.

J. HORIZONTAL DRAWER MOUNTING (Fig. 2:04)

The 5-119P4 Recording Oscillograph may be conveniently drawer-mounted in a 19-inch relay rack. The Part No. 156112 Drawer Mount Assembly may be obtained from CEC on special order. No modifications to the oscillograph are required. This mounting requires a 21-inch rack height and 22-inch rack depth. The drawer slide, when pulled all the way out, will extend 20 inches in front of the rack to permit easy adjustment of the galvanometers and oscillograph. It provides a convenient and accessible assembly when the 5-036B DATARITE Magazine is used.

K. DATARITE MAGAZINE, TYPE 5-036B (Fig. 10:06)

The function of the DATARITE is to place recorded, ready-to-read data into the hands of engineers almost simultaneously with the occurrence of the phenomena under observation. DATARITE performs this task with outstanding speed and efficiency under ordinary light conditions and provides oscillograph records of excellent trace contrast and readability.

Magazine recording speeds are variable from 0.1 to 25 inches per second, and at the maximum speed the record emerges within 0.8 seconds after exposure. DATARITE's generous capacity of 450 feet of conventional thin-base recording paper, combined with writing speeds up to 30,000 ips, satisfies the requirements of a wide variety of diversified test programs. The record emerges developed, dried, and fully visible. A latensification waiting period or further processing are not required. If a record of archival permanence is desired, a simple acid-hypo fixing rinse may be used at a later, convenient time. Fixing can be done in full daylight.

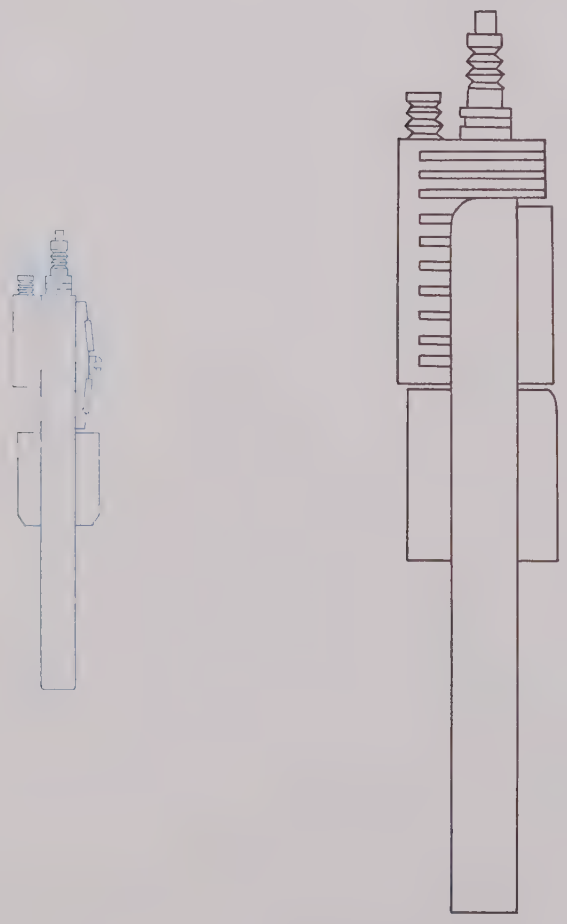
For further information see Bulletin 1598 in the Appendix.

DATARITE IS ATTACHED TO CEC'S
5-119 RECORDING OSCILLOGRAPH

FIG. 10:05

5-119P4
10-59 2061

Galvanometer Repair and Exchange Service



CONSOLIDATED ELECTRODYNAMICS CORPORATION
TRANSDUCER DIVISION *360 Sierra Madre Villa, Pasadena, California*

SALES AND SERVICE OFFICES LOCATED IN PRINCIPAL CITIES THROUGHOUT THE WORLD

CEC

Printed in USA

GALVANOMETER SERVICE

This plan has been formulated to simplify and streamline galvanometer repair and exchange services. It is designed to speed up the processes of quoting repair costs and placement of repair orders by customers.

Through analysis of statistics gathered over several years and covering the costs of many types of repairs, it has been possible to group all repairs into one of three classes and establish standard prices for each class.

CLASS I REPAIR

Class I Repair includes a thorough inspection and test of the galvanometer, followed by cleaning, adjustment for sensitivity and frequency response, and finally, a static balance to CEC standard tolerance.

SERIES	STANDARD CHARGE
7-100	$ 28.00
7-200	28.00
7-300 (Except High Temperature)	28.00
7-300 (High Temperature Galvanometers 7-350, 7-352, 7-354, 7-355, 7-381, 7-382)	39.00
7-501	39.00
7-370	50.00

CLASS II REPAIR

Class II Repair includes all the operations of a Class I Repair plus repair or replacement of such components as mirrors, lenses, insulators, turrets, leads, adjusting posts. It does not include replacement of the entire suspension assembly nor of the galvanometer body itself.

SERIES	STANDARD CHARGE
7-100	$ 44.00
7-200	44.00
7-300 (Except High Temperature)	44.00
7-300 (High Temperature Galvanometers 7-350, 7-352, 7-354, 7-355, 7-381, 7-382)	50.00
7-501	50.00
7-370	120.00

CLASS III REPAIR

7-100 SERIES

This class of repair includes any or all of the services of Class I and II, plus replacement of an entire suspension assembly or replacement of body (not both). The charge for this type of service varies with the galvanometer type.

SERIES 7-100	CHARGES
7-101	$ 94.00
7-102	94.00
7-112	110.00
7-114	110.00
7-115	127.00
7-111	94.00

SERIES 7-100	CHARGES
7-116	$ 110.00
7-117	110.00
7-118	127.00
7-119	110.00
7-120	110.00

7-200 SERIES

Class III Repairs will not be performed on 7-200 Series Galvanometers. Instruments determined to be in this classification may be exchanged as described in the Exchange Plan.

7-300 SERIES

This class of repair includes all of Class I and II plus all necessary components to give a "like new" performance. The charge for this service varies with the galvanometer type.

SERIES 7-300	CHARGES
7-312	$ 77.00
7-315	94.00
7-316	77.00
7-317	77.00
7-318	88.00
7-319	77.00
7-320	77.00
7-323	77.00
7-324	72.00
7-325	77.00
7-326	94.00
7-338	88.00
7-339	88.00
7-340	99.00
7-341	99.00
7-342	99.00
7-343	99.00
7-344	99.00
7-345	99.00

SERIES 7-300	CHARGES
7-346	$ 99.00
7-347	99.00
7-348	99.00
7-349	99.00
7-350	110.00
7-351	99.00
7-352	110.00
7-353	99.00
7-354	110.00
7-355	110.00
7-361	99.00
7-362	99.00
7-363	99.00
7-364	99.00
7-370	220.00
7-381	110.00
7-382	110.00
7-501	120.00

PRECISION BALANCE

Precision Balance, where applicable, is available for all classes of repair service at the following additional charges:

If galvanometer was originally sold with precision balance.....$11.00
If galvanometer was originally sold with standard balance and is to be converted to precision balance:

7-200.....Must be exchanged for 7-300 Series
7-300.....$16.00

EXCHANGE PLAN

A 7-200 Series galvanometer may currently be exchanged for an equivalent 7-300 Series galvanometer regardless of the condition of the inoperative unit. The only restriction is that the exchange must be made on a corresponding type basis, such as a 7-215 for a 7-315.

7-200 TYPE	EQUIVALENT 7-300 SELLING PRICE	CREDIT ALLOWED FOR 7-200	NET COST OF EXCHANGE
7-212	140.00	55.00	85.00
7-215	175.00	70.00	105.00
7-216	140.00	55.00	85.00
7-217	140.00	55.00	85.00
7-218	160.00	60.00	100.00
7-219	140.00	55.00	85.00
7-220	140.00	55.00	85.00
7-223	140.00	55.00	85.00
7-224	125.00	45.00	80.00
7-225	145.00	55.00	85.00
7-226	160.00	60.00	100.00
7-238	160.00	60.00	100.00
7-239	160.00	60.00	100.00
7-253	215.00	95.00	120.00

Precision Balance, where applicable, is available for exchange units at a net cost of $7.50. If Precision Balance is desired, the selling prices shown should be increased by $15.00 and the corresponding credit allowance should be increased by $7.50.

GALVANOMETER REPAIR CODE

The following chart lists the type of work performed or type of damage determined, with the code letter used on the billing. This information will give the customer a case history on each galvanometer.

An "X" preceding the code letter indicates Precision Balance. The class of repair is indicated by Roman numerals I, II, or III preceding the code letter.

	Code
Clean, Adjust, Rebalance	A
Clean and Adjust (oil damped)	B
Open Coil - Replace Suspension	C
Loose Lower Insulator (7-100)	D
Broken Bracket Screw (7-100)	E
Broken Bracket (7-111)	F
Broken Ground Lead	G
Loose Terminal (7-300)	H
Broken Insulator	I
Empty Oil Loop	J
Window Damaged (7-100, 7-300)	K
Broken or Missing Lens	L
Damaged Mirror	M
Damaged Body - Replace Body	N
Overdriven - Replace Suspension	O
Pole Pieces Crushed - Replace Body (7-200)	P
Temperature Limits Exceeded	Q
High Terminal Resistance	R
Suspension Damaged Beyond Repair or Not Suitable for Further Use	S
Broken or Missing Terminal	T
Damaged Stop or Stop Pin	U
Shorted Coil - Replace Suspension	V
Short to Case	Y
Signs of Mishandling	Z

A typical example of a galvanometer repair would read:

1 Type 7-318 Galvanometer Serial No. 4316 (XIII S-A)

REPAIR INFORMATION

Inquiries regarding galvanometer repair should be directed to:

Consolidated Electrodynamics Corporation
Transducer Division
1400 S. Shamrock
Monrovia, California
Attention: Repair Department

CEC **price list**

Consolidated Electrodynamics
CORPORATION
360 Sierra Madre Villa, Pasadena, California
OFFICES IN PRINCIPAL CITIES THROUGHOUT THE WORLD

Effective April 1, 1959

GALVANOMETER SPECIFICATIONS—TYPE 7-300 SERIES

Type 7-300	External Damping Resistance Required (1)	Undamped Natural Frequency	Flat (±5%) Frequency Range	Terminal Resistance (±10%)	Sensitivity At 11.5 Inch Optical Arm: Undamped d-c Sensitivity		Sensitivity At 11.5 Inch Optical Arm: System Voltage Sensitivity (2)		Static Balance (3): Standard	Static Balance (3): Special	Maximum Safe Current	Unit Price (*4)
	Ohms	cps	cps	Ohms					in/g	in/g	ma	
STANDARD GALVANOMETERS												
Magnetically Damped					μa/in	in/μa	mv/in	in/mv				
7-325	350	18.5	0-11	18	7.94	0.125	2.92	0.343	0.050	0.025	15	$145.00*
7-339	350	50	0-30	30	4.61	0.217	1.75	0.572	0.032	0.016	15	160.00*
7-315	350	100	0-60	33	12.2	0.0820	4.67	0.214	0.016	0.008	15	175.00*
7-312	350	100	0-60	40	29.9	0.0334	11.7	0.0858	0.016	0.008	25	140.00*
7-318	180	150	0-90	26	30.6	0.0327	6.29	0.159	0.012	0.006	25	160.00*
7-338	120	210	0-125	25	57.8	0.0173	8.40	0.119	0.012	0.006	50	160.00*
7-324	83	300	0-180	43	265.	0.00377	33.3	0.030	0.012	0.006	50	125.00*
7-319	25	585	0-350	26	426.	0.00115	21.7	0.046	0.012	0.006	50	140.00*
Fluid Damped					ma/in	in/ma	v/in	in/v				
7-323	1000	1000	0-600	26	2.50	0.400	2.56	0.390	0.008		100	140.00
7-320	200	1000	0-600	26	2.30	0.434	0.521	1.92	0.008		100	140.00
7-316	200	2000	0-1200	25	9.17	0.109	2.05	0.487	0.005		100	140.00
7-317	28	3700	0-2200	25	40.6	0.0246	2.16	0.464	0.005		100	140.00
7-326	55	5000	0-3000	53	31.8	0.0314	3.44	0.291	0.005		100	160.00
HIGH PERFORMANCE GALVANOMETERS												
Magnetically Damped					μa/in	in/μa	mv/in	in/mv				
7-349	350	10	0-6	130	1.62	0.617	0.778	1.286	0.026		15	215.00
7-351	350	20	0-12	33	2.66	0.375	1.02	0.982	0.016		15	185.00
7-341	350	100	0-60	47	6.12	0.163	2.43	0.411	0.012		10	180.00
7-342	350	225	0-135	86	10.7	0.0935	4.67	0.214	0.008		15	195.00
7-346	350	320	0-190	60	26.7	0.0375	10.9	0.0914	0.008		15	180.00
7-344	180	150	0-90	45	9.75	0.103	2.20	0.455	0.008		15	180.00
7-345	180	335	0-200	84	23.9	0.0418	6.29	0.159	0.008		15	180.00
7-348	120	100	0-60	98	6.71	0.149	1.46	0.683	0.008		10	180.00
7-347	120	225	0-135	90	15.1	0.0662	3.17	0.315	0.008		15	165.00
7-343	120	335	0-200	61	33.3	0.0300	6.06	0.165	0.008		15	180.00
Fluid Damped					ma/in	in/ma	v/in	in/v				
7-364	200	833	0-500	69	0.400	2.50	0.107	9.37	0.008		50	165.00
7-363	200	1670	0-1000	69	2.0	0.50	0.533	1.875	0.005		100	165.00
7-362	200	4150	0-2500	69	12.0	0.0833	3.23	0.31	0.005		100	165.00
7-361	55	8000	0-5000	57	46.1	0.0217	5.29	0.189	0.005		100	205.00
HIGH TEMPERATURE GALVANOMETERS (5)												
Magnetically Damped					μa/in	in/μa	mv/in	in/mv				
7-350	350	20	0-12	36.1	2.67	0.375	1.03	0.970	0.020		15	225.00
7-352	350	100	0-60	42.1	12.1	0.0826	4.74	0.211	0.016		15	215.00
7-354	180	150	0-90	36.1	29.9	0.0344	6.45	0.155	0.012		25	205.00
7-355	120	225	0-135	121	14.2	0.0704	3.42	0.292	0.008		15	225.00
Fluid Damped					ma/in	in/ma	v/in	in/v				
7-381	1000	1000	0-600	28	2.5	0.40	2.56	0.390	0.008		100	205.00
7-382	55	5000	0-3000	65	32.2	0.0311	3.86	0.259	0.005		100	215.00
SPECIALIZED GALVANOMETERS												
7-353	An integrating-type galvanometer whose response is inversely proportional to frequency from 8 to 800 cps. See Bulletin 1517.											215.00
7-370	A computing-type galvanometer whose response is either the product, sum, or difference between two signals. Flat response from 0-800 cps. See Bulletin 1605.											375.00

NOTES:

(1) For 64% critical damping.

(2) The System Voltage sensitivity relates the galvanometer trace deflection (inches) on the record to the open-circuit voltage of a transducer having a source resistance equal to (1) above. (Previous CEC galvanometer-characteristics charts have stated voltage sensitivity in terms of voltage applied to the coil. These values should not be compared to the present sensitivities, since the two are based on different circuitry conditions.)

(3) Deflection of trace in inches per "g" at 11.5-inch optical arm.

(*4) Add $15.00 for special balance.

(5) Specifications based on operation at 175°F ±25°F.

Unused slots between active galvanometers may be filled with Types 7-002 or 7-003 listed below. The Type 7-003 is used to maintain specification sensitivity and magnetic-damping characteristics for extremely high accuracy tests. The Type 7-002 incorporates standard pole pieces to maintain uniform flux and does not affect the characteristics of the active galvanometers being used.

TYPE 7-003 DUMMY GALVANOMETER. . . . . $ 15.00

Dummy galvanometers (with no internal mechanism) are equipped with standard pole pieces.

TYPE 7-002 STATIC GALVANOMETER REFERENCE TRACE. 50.00

Static galvanometer reference traces (equipped only with a static mirror) are used to provide fixed reference traces at any point on the record.

TYPE 7-004 DYNAMIC REFERENCE TRACE 120.00

Dynamic reference trace galvanometer (equipped with movement mirror) 28 ma per inch employed to provide dynamic reference trace on the record.

Plug-in damping resistors are available for use in circuits where the driving-source impedance does not provide proper galvanometer damping. Units are furnished on order to the specific resistance value required and are connected in either shunt or series form.

SHUNT RESISTOR PART NO. 49541--(specify ohms required) 8.75

SERIES RESISTOR PART NO. 49542--(specify ohms required) 8.75

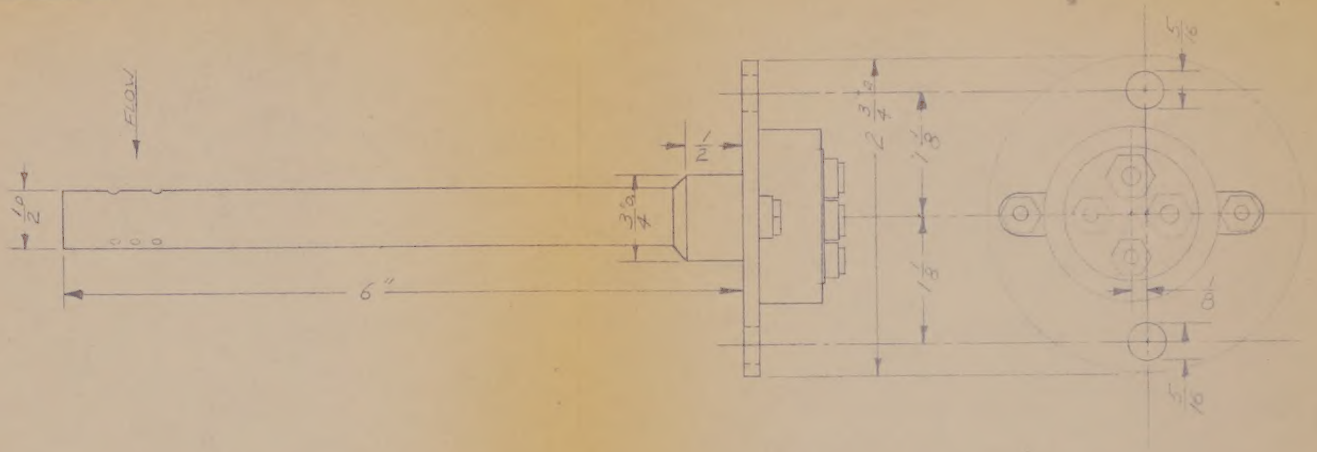
TERMS: Net 30 days.

TAXES: All prices are subject to state and local taxes.

NOTICE: Prices are subject to change without notice. Prices are f. o. b. Shipping Point.

NOTICE. When Government drawings, specifications, or other data are used for any purpose other than in connection with a definitely related Government procurement operation, the United States Government thereby incurs no responsibility nor any obligation whatsoever; and the fact that the Government may have formulated, furnished, or in any way supplied the said drawings, specifications, or other data, is not to be regarded by implication or otherwise as in any manner licensing the holder or any other person or corporation, or conveying any rights or permission to manufacture, use or sell any patented invention that may in any way be related thereto.

REVISIONS				
SYM	ZONE	DESCRIPTION	DATE	APPROVED



QUANTITY PER ASSY	PART NO.	DESCRIPTION	CODE IDENT	MATERIAL OR NOTE	SPECIFICATION OR NOTE	UNIT WT	ZONE	ITEM NO.
ASSY DASH NO.								

LIST OF MATERIAL

MECHANICAL PROPERTIES	
YP	
TS	
EL 2	
RA	
BH	
RH	

DIMENSION LIMITS AFTER PLATING
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
TOLERANCES ON FRACTIONS | DECIMALS | ANGLES

RMS FINISH UNLESS OTHERWISE SPECIFIED REMOVE SHARP EDGES AND BURRS ✓

MATL & SPEC

FINISH & SPEC

HEAT TREATMENT

	SIGNATURE	DATE
DRAWN		12-18-63
DESIGN		
CHECKED		
STRESS		
SUPV		
ENGR		
DESIGN ACTIVITY APPROVAL		
APPROVAL		

DASH NO.	NEXT ASSY	QTY N.A.	FINAL ASSY	QTY F.A.

APPLICATION

PROJ NO.	DESIGN S.P. NO.	

COOK TECHNOLOGICAL CENTER
A DIVISION OF
COOK ELECTRIC CO., CHICAGO, ILLINOIS

JET ENGINE COMBUSTION CHAMBER TEMPERATURE PROBE

CODE IDENT NO.	SIZE	
71688	B	SK 24870

SCALE	WT ACT	WT CALC	SHEET

K+E ALBANENE 180L ® TRACING PAPER